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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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1168
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CULVER STREET WORKS, COLCHESTER.
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ENGINES for Torpedo Boats, Yachts, Launches.
BOILER FEED PUMPS.
See advertisement page 18.
PATENT WATER-TUBE BOILERS.
AUTOMATIC FEED REGULATORS.
And Auxiliary Machinery as supplied to the Admiralty. 2179

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OF ALL DESCRIPTIONS.
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Werf Conrad, HAARLEM, HOLLAND.
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See half-page Advert. last week and next week. 1382

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Thos. Piggott & Co., Limited,
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See Advertisement last week, page 90.

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PATENT BOILERS *See Page 73.* 1293
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Tank Locomotives.
Specification and Workmanship equal to Main Line Locomotives.
R. & W. HAWTHORN, LESLIE & CO. LTD., ENGINEERS, NEWCASTLE-ON-TYNE. 1133

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MULTITUBULAR AND CROSS-TUBE TYPES.
See page 17. 1134

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COVENTRY. 610

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Iron and Steel
Tubes and Fittings.
Sole Licensees in Great Britain for the manufacture of "Armco" Rust and Corrosion Resisting Iron Tubes. 817
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See Advertisement, page 77, Nov. 23.

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PASSENGER AND CARGO STEAMERS.
SHALLOW DRAFT VESSELS. 1559

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Gear Cutting.
Worm Wheels cut up to 13 ft. diam.
Bevel and Mitre Wheels planed up to 3 ft. diam.
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FOR SHEET AND PLATE WORKING.
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OIL FUEL APPLIANCES,
Systems
PRESSURE, AIR, STEAM
For Boilers of all types.
KERMODES LIMITED,
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Naval Outfits a Speciality, also for Merchant Ships, for Factories, Locomotives, and Industrial Process Furnaces of all kinds.
Supplied to the British and other Governments.
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Locomotives Tank Engines
designed and constructed by MANNING, WARDLE AND COMPANY, LIMITED, Boyne Engine Works, Leeds. Od. 2487
See their Illus. Advertisement, page 93, last week.
RAILWAY AND TRAMWAY ROLLING STOCK.
Hurst, Nelson & Co., Ltd.
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(ESTABLISHED 1864.)
BUILDERS of RAILWAY CARRIAGES & WAGONS
MAKERS of WHEELS and AXLES of all kinds.
RAILWAY WAGONS FOR HIRE.
Chief Works and Offices:
WISHAW, near GLASGOW.
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GEARS OF EVERY DESCRIPTION.
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1357
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London Office: 101, LEADENHALL ST., E.C. 3.
Works: BURNT MILL, near HARLOW, ESSEX.
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Refrigerating and Ice-making Machinery.
Feed Water Heaters.
Evaporators.
Fresh Water Distillers.
Main Feed Pumps.
Combined Circulating and Air Pumps.
Auxiliary Surface Condensers.
&c., &c. 1586

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MILLWALL, LONDON, E. 1216
GENERAL CONSTRUCTIONAL ENGINEERS,
Boilers, Tanks, & Mooring Buoys
STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETED STEAM AND VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

IRON & STEEL
Tubes AND Fittings AND Steel Plates.
STEWARTS AND LLOYDS, Ltd.
GLASGOW - BIRMINGHAM - LONDON.
See Advertisement, page 52. 1111

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PETERBOROUGH.
STEAM ENGINES AND TURBINES.
GAS AND OIL ENGINES.
AIR COMPRESSORS.
REFRIGERATING PLANT. 1475
See Advertisement, page 53, Nov. 23.

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CELITE PRODUCTS CORPORATION, Windsor House, Westminster, S.W.1. 1675
See our Illustrated Advertisement, Nov. 16.

Unique Opportunity.
FOR SALE,
at CONSIDERABLY REDUCED PRICES, a Number of
New Electric Portal Harbour Cranes,
Capacity 3 tons and 1½ tons, at maximum radius 54 ft.
Built to a first-class Colonial Specification.
Ready for IMMEDIATE DELIVERY, including spare parts.
Full particulars on application.
Address, C 212, Offices of ENGINEERING.

Rosser and Russell, Ltd.,
MECHANICAL ENGINEERS,
QUEEN'S WHARF, HAMMERSMITH, W.
Undertake SPECIAL MACHINE WORK of any description.
WELL EQUIPPED SHOP.
LATHE WORK up to 10 ft. diameter.
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For Your Repairs or any
SPECIAL MACHINERY, try
THOMAS HUNT & SONS,
Albion Ironworks,
Bridge Road West, Battersea, S.W. 11.
Est 1854. 1792

Electric Lifts
(UP TO 35 TONS.)
1357
S. H. HEYWOOD & CO., LTD., REDDISH.

Machine Cut Gears
SPUR AND SPIRAL.
Worms and Worm Wheels.
Worm and Spur Reduction Sets.
High Grade Work at Reasonable Charges.
STORR & EVANS,
Grove Road, Hunslet, Leeds. 1573

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CARELS DIESEL & STEAM ENGINES (LONDON) LTD., Kinnaird House, 1, Pall Mall East, S.W. 1. 1130
Telephone: Regent 3484.

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ENGINEERS, IRLAM, MANCHESTER.
FEED WATER HEATERS, CALORIFIERS, EVAPORATORS, CONDENSERS, AIR HEATERS, } ROW'S PATENTS.
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SYPHONIA STEAM TRAPS, REDUCING VALVES.
High-class GUNMETAL STEAM FITTINGS.
WATER SOFTENING and FILTERING. 5723

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LAND AND MARINE
YARROW BOILERS. 1553

Matthew Paul & Co., Ltd.,
LEVENFORD WORKS, Dumbarton. 1483
See Full Page Advt., page 38, Nov. 9.

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HALESOWEN. 7116

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For Production of SHEET METAL WORK, COINAGE, CARTRIDGES AND GUNPOWDER.
Foundry, Works, and Showrooms: BIRMINGHAM.
See advert., page 82, Nov. 2. 8195

Head, Wrightson & Co.,
LIMITED.
See Advertisement page 56. 2402

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T. SUMMERSON & SONS, LIMITED, DARLINGTON. 1312

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Lockwood Huddersfield.
HIGH CLASS
Machine Cut Gearing
FOR EVERY PURPOSE. 1440

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AUCTIONEERS, VALUERS AND SURVEYORS for ENGINEERING AND ALLIED TRADES and INDUSTRIAL PROPERTIES. 9686
63 and 64, CHANCERY LANE, LONDON, W.C.2.

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(ELECTRIC). 1357
S. H. HEYWOOD & CO., LTD., REDDISH.

MACHINE CUT
Gears.
Spurs, Bevels, Spiral, Worm and Worm Wheels.
HIGHFIELD GEAR CUTTING CO. (DEPT. E), Huddersfield. 1645

Centrifugals.
Pott, Cassels & Williamson,
MOTHERWELL, SCOTLAND. 1678
See half-page Advertisement, page 68, Nov. 23.

The Manchester Steam Users' ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.

Chief Engineer: C. E. STROMEYER, M.I.C.E.

Founded 1854 by Sir WILLIAM FAIRBAIRN.

Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 1311

SUGAR FACTORY, LITTLEPORT (CAMBS.)

Messrs. Hal Williams and

Company, Factory House, High Holborn, London, the Architects and Engineers for the new sugar factory, desire to thank all those who have communicated with them offering labour and materials required in the construction, and use this method of doing so as the numbers are too numerous to permit of individual letters. Communications have been carefully noted, and in the meantime representatives will conserve their own time and that of others by refraining from calling or telephoning. C 271

Correspondence Courses for

Inst.Civil Engrs., Inst.Mech.E., London Univ. (Matric., Inter., B.Sc.), and All ENGINEERING EXAMINATIONS personally conducted by Mr. TREVOR W. PHILLIPS, B.Sc. (Honours), Assoc. M.Inst.C.E., M.R.S.I., F.R.S.A., etc., Also Day Tuition in Office. Excellent results at all Exams. Courses may commence at any time, and all Students receive individual tuition.—For full particulars apply to 8/11, TRAFFORD CHAMBERS, 58, SOUTH JOHN STREET, LIVERPOOL. 1296

Engineering Examinations.—

Day, Evening or Correspondence Courses of Preparation for all examinations. Thousands of successes during the past eighteen years.—G. P. KNOWLES, M.B.E., B.Sc., A.M.I.C.E., etc., 39, Victoria Street, Westminster, S.W.1. C188

Engineering Salesmanship

and SALES MANAGEMENT.—Write for brochure describing our special Course of training for posts of unlimited scope in this lucrative field.—DIRECTOR, Institute of Engineering Salesmanship, 330, Oxford Road, Manchester. 1723

TENDERS.

GREAT NORTHERN RAILWAY (IRELAND).

TENDERS FOR SLEEPERS.

The Directors are prepared to receive

Tenders for the Supply of

BALTIC SOFTWOOD SLEEPERS, 9 ft. by 10 in. by 5 in. creosoted and uncreosoted.

Tenders, made out on forms supplied by the Company, should be delivered, under sealed cover, endorsed "Tender for Sleepers," not later than Ten a.m. on Thursday, 13th December.

The Directors do not bind themselves to accept the lowest or any Tender.

J. B. STEPHENS,
Secretary.

Amiens Street Station,
Dublin.
23rd November, 1923. C 250

COUNTY BOROUGH OF WALLASEY.

ELECTRICITY DEPARTMENT.

CONTRACT FOR OVERHEAD ELECTRIC TRAVELLING CRANE.

The Corporation of Wallasey are prepared to receive

Tenders for the Supply,

DELIVERY and ERECTION of a 30 Ton OVERHEAD ELECTRIC TRAVELLING CRANE at their Generating Station, Limekiln Lane, Wallasey.

Full information and copies of the specification can be obtained on application at the office of the Engineer and Manager, Mr. B. T. HAWKINS, Electricity Department, Sea View Road, Wallasey.

Sealed Tenders on the form embodied in the specification, addressed to the Chairman of the Electricity Committee, c/o Town Clerk, Town Hall, Wallasey, and endorsed "Tender for Overhead Crane" to be delivered per post, not later than the morning of the 10th December, 1923.

By Order,
GEO. LIVSEY,
Town Clerk.

Town Hall,
Wallasey.
22nd November, 1923. C 252

METROPOLITAN WATER BOARD.

DISPOSAL OF OBSOLETE AND SURPLUS PLANT.

The Metropolitan Water Board invite

Tenders for the Purchase

and REMOVAL of OBSOLETE and SURPLUS PLANT (comprising Engines, Boilers and Scrap Metal, etc.) situate at the works of the Board at West Molesey, Sunbury, Nunhead and Hammersmith.

The Plant may be seen at the above mentioned works at any time between Nine a.m and Four p.m. on weekdays (Saturdays excepted), on application to the Engineer in charge of the works concerned.

Tender Forms, with Conditions of Contract and Schedule containing particulars of the plant for disposal, may be obtained from the Chief Engineer, Metropolitan Water Board, 173, Rosebery Avenue, E.C.1, by personal application (Room No. 165) or upon forwarding a stamped addressed brief envelope.

Tenders must be on the official form, enclosed in sealed envelopes, addressed to "The Clerk of the Board," Metropolitan Water Board, New River Head, 173, Rosebery Avenue, E.C.1, endorsed "Tender for Obsolete and Surplus Plant," and delivered at offices of the Board not later than Eleven a.m. on Friday, 14th December, 1923.

The Board do not bind themselves to accept the highest or any Tender.

G. F. STRINGER,
Clerk of the Board.

Offices of the Board,
New River Head,
173, Rosebery Avenue, E.C.1.
23rd November, 1923. C 270

BOROUGH OF ST. HELENS.

ELECTRICITY DEPARTMENT.

The Electricity Committee of the above Council invite

Tenders for the Supply and

INSTALLATION at their Croppers Hill Power Station, St. Helens, of ONE 6500 Kw. CONTINUOUS MAXIMUM RATED TURBO ALTERNATOR, complete with Condensing Plant and Auxiliaries.

Copies of Specification and Form of Tender may be obtained from the Borough Electrical Engineer and Manager, Croppers Hill Power Station, St. Helens, upon payment of a deposit of £2 2s. which will be returned only upon receipt of a *bona fide* Tender.

Tenders, sealed and endorsed "Tender for Turbine Plant," are to be addressed to the Chairman of the Electricity Committee, Town Hall, St. Helens, and delivered there not later than Saturday, 15th December, 1923.

The Committee do not bind themselves to accept the lowest or any Tender.

W. H. ANDREW,
Town Clerk.

Town Hall,
St. Helens.
27th November, 1923. C 274

BOROUGH OF ST. HELENS.

ELECTRICITY DEPARTMENT.

The Electricity Committee of the above Council invite

Tenders for the Supply and

INSTALLATION at their Croppers Hill Power Station, St. Helens, of TWO WATER TUBE BOILERS, complete with Superheaters, Economisers, Induced Draught Fan, and Boiler Accessories, Steel Chimney, Structural Steel Boiler House Building and other works.

Copies of Specification and Form of Tender may be obtained from the Borough Electrical Engineer and Manager, Croppers Hill Power Station, St. Helens, upon payment of a deposit of £2 2s. which will be returned only upon receipt of a *bona fide* Tender.

Tenders, sealed and endorsed "Tender for Boiler Plant," are to be addressed to the Chairman of the Electricity Committee, Town Hall, St. Helens, and delivered there not later than Saturday, 15th December, 1923.

The Committee do not bind themselves to accept the lowest or any Tender.

W. H. ANDREW,
Town Clerk.

Town Hall,
St. Helens,
27th November, 1923 C 275

COUNTY OF LONDON.

The London County Council invites

Tenders for :—

(A) The MANUFACTURE, SUPPLY, DELIVERY, ERECTION on GANTRY, TESTING and MAINTENANCE (for six calendar months) of ONE THREE-TON THREE-MOTOR TYPE OVERHEAD TRAVELLING CRANE, for the Council's Tramway Central Repair Depot, Charlton, London, S.E.

(B) The MANUFACTURE, SUPPLY, DELIVERY, TESTING and MAINTENANCE (for six calendar months) of ONE THIRTY-HUNDREDWEIGHT MOTOR-DRIVEN PORTABLE WORKSHOP CRANE for the Council's Tramway Central Repair Depot.

The Specification and Drawings, Form of Contract, etc., may be obtained from the General Manager, London County Council Tramways, Victoria Embankment, W.C.2, upon payment of a deposit of £2. This amount will be returnable only if a *bona fide* Tender is submitted and not withdrawn.

Particulars of the work may be obtained at the Tramways Offices, Victoria Embankment, before the payment of the deposit

Tenders must be delivered to the Clerk of the Council at the County Hall, Westminster Bridge, S.E. 1, not later than Four p.m., on Monday, 31st December, 1923. No Tender received after that time will be considered. The Council does not bind itself to accept the lowest or any Tender.

JAMES BIRD,
Clerk of the London County Council. C 244

ABERDEEN CORPORATION WATER WORKS.

EXTENSIONS 1920.

Contract No. 17 - New Intake.

The Town Council of Aberdeen are prepared to receive

Tenders from Competent

Persons willing to enter into a Contract for the CONSTRUCTION of an INTAKE and SCREENING HOUSE, a 5 feet diameter CONDUIT, and ancillary Works alongside the River Dee at Cairnton, Invercannie.

The Drawings may be inspected and Specification, Schedule of Quantities, and Form of Tender obtained, on and after 4th December, 1923, on application at the Water Engineer's Office, 41½, Union Street, Aberdeen. Early application is desirable, and no Specification will be given out after 13th December.

For each Specification a deposit of Five Pounds Sterling will be required, which sum will, after a Tender has been accepted, be returned to the Tenderer, provided that he shall have sent in a *bona fide* Tender, based on the drawings, specification and schedule of quantities provided, with the schedule of quantities fully priced out in detail, and shall not have withdrawn the same.

The employment of labour shall be in accordance with conditions of the Unemployment Grants Committee.

Tenders on the forms prescribed, and enclosed in securely sealed envelopes, endorsed "Tender for New Intake" are to be addressed to the undersigned. No Tender delivered after Five p.m. on 28th December, 1923, will be considered.

The Town Council do not bind themselves to accept the lowest or any Tender.

No person should Tender unless thoroughly experienced in the actual construction of extensive public works.

GEORGE MITCHELL, M.Inst.C.E., F.G.S.,
Water Engineer.

Water Engineer's Office,
41½, Union Street, Aberdeen.
24th November, 1923. C 263

The Director-General,

India Store Department, Branch No. 16, Belvedere Road, Lambeth, S.E.1, REQUIRES :—

3000 RAILWAY WAGONS.
60 LOCOMOTIVES.

Tenders are being called for simultaneously in India.

Tenders for the wagons due on Tuesday, the 22nd January, 1924.

Tenders for locomotives due on Tuesday, the 26th February, 1924.

TENDERS are also REQUIRED for :—
WHEELS AND AXLES. Required urgently.
Tenders due on the 7th December, 1923.
Tender forms obtainable from above. C 284

BENGAL-NAGPUR RAILWAY COMPANY LIMITED.

The Directors are prepared to receive

Tenders for :—

SIX BRASS FINISHERS' CAPSTAN LATHES.

Specification and Form of Tender can be obtained at the Company's Offices, 132, Gresham House, Old Broad Street, London, E.C.2, on or after 26th November, 1923.

A fee of 10/- will be charged for the Specification, which is NOT returnable.

Tenders must be submitted not later than NOON, on Friday, 7th December, 1923.

The Directors do not bind themselves to accept the lowest or any Tender.

By Order of the Board,
R. C. VOLKERS,
Secretary. C 256

GREAT SOUTHERN & WESTERN RAILWAY.

The Directors of the Great Southern & Western Railway, Ireland, are prepared to receive

Tenders for the following

MATERIAL—
4750 tons 90 lbs. Bull-head Rails, British Standard Section.
125 tons Fishplates for British Standard 90 lbs. Bull-head Rails.
150 tons Fishplates for 87 lbs. Bull-head Rails.
100 tons Fishplates for 74 lbs. Flat Foot Rails.
3250 tons Cast Iron Chairs.
950 tons Cast Iron Soleplates.

Specifications, Forms of Tender, and Drawings can be obtained on application to the Company's Chief Engineer, Mr. J. F. SIDES, Inchicore, Dublin.

Tenders should be sent so as to reach the undersigned not later than Ten a.m., on the 12th December, 1923, and should be endorsed on the outside "Tenders for....."

The Directors do not bind themselves to accept the lowest or any Tender.

C. E. RILEY, Secretary,
Secretary's Office, Kingsbridge, Dublin. C 290

CITY OF NOTTINGHAM—WATER DEPARTMENT.

DERWENT VALLEY SUPPLY.
(SECOND INSTALMENT.)

EXTENSION OF FILTRATION PLANT.

The Water Committee invite

Tenders from Manufacturers

experienced in the design of Mechanical Filtration Plants, for the CONSTRUCTION and ERECTION of FILTERS capable of dealing with three million gallons per 24 hours, to be erected at their existing Filter Works in the Parish of Eastwood, Notts.

Plans, Drawings, Conditions of Contract, Specifications, Schedule and Form of Tender may be obtained on application to Mr. F. W. DAVIES, Engineer and General Manager, Water Department, Castle Boulevard, Nottingham, accompanied by a cheque for Five Guineas, which will be refunded on receipt of a *bona fide* Tender, and the return of all documents.

Sealed Tenders, endorsed "Tender for Mechanical Filters," must be delivered to me at my Office, not later than Friday, the 21st day of December, 1923.

The Committee do not bind themselves to accept the lowest or any Tender.

W. J. BOARD,
Town Clerk,

Guildhall,
Nottingham.
26th November, 1923. C 258

CITY OF NOTTINGHAM. WATER DEPARTMENT.

PIPE-LAYING.

The Water Committee invite

Tenders from Competent

Persons for LAYING and JOINTING about 452 yards of 6 in., 800 yards of 16 in., and 14,700 yards of 18 in. CAST-IRON PIPES, together with the FIXING of the necessary VALVES, etc., and other appurtenant work in connection with the second instalment of water from the Derwent Valley Supply, and the Supply to Colwick Hill Reservoir.

Plans, Drawings, Conditions of Contract, Specifications, Schedules, and Forms of Tender may be obtained on application to Mr. F. W. DAVIES, Engineer and General Manager, Water Department, Castle Boulevard, Nottingham, accompanied by a cheque for Five Guineas, which will be refunded on receipt of *bona fide* Tenders and the return of all documents.

Sealed Tenders, endorsed "Tender for Pipe-Laying," must be delivered to me at my Office, not later than Friday, the 14th day of December, 1923.

The Committee do not bind themselves to accept the lowest or any Tender.

W. J. BOARD,
Town Clerk.

Guildhall,
Nottingham.
26th November, 1923. C 259

APPOINTMENTS OPEN.

Wanted, Salesman, with Good

connection amongst steam users to sell important feed-water accessory plant. Some knowledge of water chemistry and engineering desirable, but applicant must have proved record of success as interviewer and order-getter. No others need apply. Salary, commission, and expenses.—BOX, U.W.S., c/o HOPWOODS, 170, Fleet Street, E.C.4. C 269

CAPE TECHNICAL COLLEGE, CAPE TOWN.

Applications are Invited for

SENIOR LECTURER in Electrical Engineering. Salary £450 - 3 - 650.

Applications, which will be received up to the 10th December, 1923, must be accompanied by certified copies of testimonials of works and teaching experience and should state age of applicant.

The holder of this post will be required to join the Government Provident Fund and must contribute 6 per cent. of his salary.

Two years' probation, subject to six months' notice either side; afterwards, three months' notice.

£50 allowed for travelling expenses, but a proportionate amount of this to be repaid if the contract is terminated in less than two years.

Teaching experience may be taken into consideration when deciding the initial salary.

Apply in first case to Messrs. CHALMERS, GUTHRIE & CO., LTD., 9, Idol Lane, London, E.C. C 225

KENT EDUCATION COMMITTEE.

ERITH TECHNICAL INSTITUTE.

Required at Once, a Teacher

of Motor Car Engineering for work on Thursday evenings; also a TEACHER of Heat Engines (Advanced) Monday evenings, throughout the session.

Salary in accord with the scale of the Kent Education Committee.—Apply, at once, stating full particulars of qualifications and experience, to the Principal, Technical Institute, Belvedere.

E. SALTER DAVIES,
Director of Education.
27th November, 1923. C 277

Works Manager

REQUIRED for the FEDERATED MALAY STATES GOVERNMENT RAILWAY for three years with possible permanency. Salary $350 a month plus a strictly temporary cost of living allowance amounting to 10 per cent. of salary in the case of single men and for married men 20 per cent. The Government rate of exchange is now 2s. 4d. to the dollar, but the purchasing power of the dollar in Malaya is considerably less than that of 2s. 4d. in the United Kingdom. Free passages, and if married, for wife and children also, not exceeding four persons beside the candidate selected. Candidates, age 30–35, must have served an apprenticeship in the Locomotive Department of a British Railway, or with a private firm of Locomotive Builders. They should have had experience in Works Management, and, should not only have had a sound Engineering training and possess practical knowledge of the work indicated, but should also have a thorough grounding of the business side, and be able to carry on the re-organization of workshop methods under the direction of the Locomotive Superintendent. The workshops are electrically driven, on a three-phase system, and Stone's system of Train Lighting is in use. A knowledge of the electrical side of the work is therefore also desirable.

Apply at once, by letter, stating age and particulars of experience, to THE CROWN AGENTS FOR THE COLONIES, 4, Millbank, Westminster, London, S.W.1, quoting M/12249. C 247

ADMINISTRATIVE COUNTY OF LONDON.

The London County Council invites

Applications from Persons

experienced in the inspection and testing of Steam Boilers, Economisers, etc., for a POSITION of TECHNICAL ASSISTANT on the permanent staff of its Chief Engineer's Department. Candidates must be not more than 40 years of age on the latest date for receiving applications and should have been trained as mechanical engineers by apprenticeship. Other things being equal, preference will be given to holders of a Board of Trade Seagoing Engineers' First-class Certificate.

The salary will be £250 a year, rising by annual increments of £15 a year to £310 a year, and thence by annual increments of £20 a year to £350 a year with a possibility of promotion on the occurrence of a vacancy. Salary is based on pre-war conditions, and is subject at present to temporary additions on the Civil Service scale, fluctuating according to the cost of living. The total commencing remuneration is, on the present basis, about £369 a year. The next revision of the temporary additions will take place not later than 1st March, 1924.

Members of the Council's staff may apply. Due weight will be given to the claims of those candidates who served or attempted to serve in H.M. Forces during the Great War. Candidates who did not serve in H.M. armed forces must be natural-born British subjects.

Apply for forms (containing full details) to the Clerk of the Council; The County Hall, Westminster Bridge, S.E. 1. Stamped addressed foolscap envelope necessary. Forms must be returned not later than Eleven a.m., on 21st December, 1923. Canvassing disqualifies.

JAMES BIRD, C 261
Clerk of the London County Council.

BIGGLESWADE WATER SUPPLY.

MECHANICAL ENGINEER.

THE BIGGLESWADE WATER BOARD and the BIGGLESWADE RURAL DISTRICT COUNCIL invite

Applications from Persons

who have been trained as Mechanical Engineers for the APPOINTMENT of SUPERINTENDENT OF THE WATERWORKS.

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Salary £350, increasing £25 per annum up to £450 and an allowance of £30 per annum for travelling if a Motor Car or Motor Cycle is used.

Applications, stating age and particulars of the candidate's career, with copies of three testimonials, must be delivered to the undersigned at his Office at Biggleswade, Beds, on or before the 15th December next. Canvassing not allowed.

HENRY CHAUNDLER,
Clerk to the Biggleswade Water Board and the Biggleswade Rural District Council. C 255

THE GREAT EARTHQUAKE IN JAPAN.

By T. W. T. Tuckey, M.Inst.C.E.

Some very exaggerated accounts of the earthquake which devastated the cities of Tokyo and Yokohama on September 1 last, appear to have been received abroad, with the result that there have been many sensational statements in the press, and even eminent engineers have given utterance to opinions which they would hardly have held, if they had been acquainted with the actual facts.

It would be quite impossible to overstate the magnitude of the disaster which fell upon the cities of Tokyo and Yokohama, or the scenes of horror which accompanied the devastation. Nearly half the city of Tokyo was destroyed and the whole of the city of Yokohama, yet many of the headlines in newspapers which are now reaching us from abroad, are without justification.

The writer, who was in the country at the time of the earthquake, had an opportunity shortly afterwards of visiting both Tokyo and Yokohama and of inspecting many of the ruined structures, and also many which survived. A short description of what was observed may be interesting, and serve to re-assure people who believe that reconstruction on permanent lines is impossible.

In order to clear the ground, it may be stated at once—that there never was any tidal wave either at Tokyo or Yokohama, that no mountains were split open, and no islands submerged—that Yokohama harbour was not totally destroyed, and the bottom did not rise several feet—that the earth did not open and swallow up hotels—and although people were on short commons for some days, that there was no starvation.

In judging the effects of an earthquake in Japan, it should be remembered that hardly anything in the country is built for permanence. The whole country is in a state of unstable equilibrium. The sides of the hills are too steep and slides develop on the slightest provocation. Many of the streams are uncontrollable, and the valleys are liable to flood. Earthquakes and typhoons are frequent and volcanoes abound. Having to exist under such adverse conditions, the Japanese apparently decide that to make anything strong would be a waste of money. With the exception of the Government Railways and a few other modern works, permanence is not attempted. Roadways and bridges are regularly washed away after a storm, and it is looked on as quite natural. Houses are so fragile that if a motor car collides with one it kills the inmates. Even the temples are constantly being renewed. In the cities a few permanent structures have been attempted, but formerly there were no more building regulations than we had in Europe in the stone age. Tokyo's building regulations were to come into force on the day of the earthquake!

In the whole of Japan there are only a few hundred buildings of brick or masonry with any pretension to solidity. The vast bulk of the houses in the country are constructed entirely of wood, except for their tiled roofs. In recent years a great many large and pretentious buildings have been put up in the cities of the type which used to be adopted for temporary exhibition buildings in Europe. The Cinema theatres are mostly of this type. Plastered in imitation of stone, these buildings look imposing from the street, but are as fragile and as inflammable as the ordinary wooden house.

The construction of the ordinary wooden Japanese house is so flimsy, that it has to be seen to be believed in. Of one, two or three stories, but mostly of only one; the framework is made of very light uprights secured, by tenons only, to other light horizontal members at floor and ceiling. One or more sides are closed permanently with thin planks laid either horizontally or vertically and secured by nails. The other sides are entirely open and can be closed by sliding panels. The floors are wood, and the ceilings are wood, and inside divisions are of wood and paper. Charcoal fires are used in fireproof receptacles, some fixed and some portable, which are placed on the wooden floors, or in some cases sunk into them. There is not a diagonal timber in the frame work, or a bracing of any description. No bolts are used, and the only stiffness the structure possesses is due to the strength of the tenons which hold the members of the frame together. When a severe shock causes these tenons to break, the structure closes up like a jack knife and pins down any occupants who do not escape quickly. As the charcoal fires are also pinned between the wooden walls and the wooden floor, it is natural that fires should start. It is almost inconceivable that up to August 31, 1923, such buildings were still being constructed in the capital city of Tokyo.

The Japanese temples, which stand up very well against earthquakes and storms, are also built of wood, and have nothing but vertical and horizontal timbers in their structure. They are, however, built of very massive timbers, the uprights usually round baulks of large diameter, and the rectangular horizontal members, also of heavy substance, are carried right through them, often without any diminution of section. Wedges are driven on top of the horizontal members, and the whole structure is strong, but very costly. The architecture of the temples is Chinese, which probably accounts for their massive construction.

The brick buildings in Tokyo and Yokohama only date from about half a century ago, when merchants in the foreign settlement of Yokohama put up a few brick buildings to suit their ideas, which were very different from those of the Japanese. Nothing was known at the time about the effects of earthquakes in Japan, and apparently little professional advice was available. The workmanship was necessarily inferior, and the materials poor. No addition to the thickness of the walls was made to compensate for these defects; but unfortunately the buildings stood, and survived minor shocks of earthquake; with the result that many later builders were encouraged to put up equally weak structures. Other buildings in the settlement area at Yokohama were wooden-framed structures, mostly two stories in height, the framework constructed very much on Japanese lines, with an almost entire absence of bracing. Many of these were weighted with flat tiles nailed to the woodwork and plastered over in imitation of cut stone. Probably many of the early buildings were intended by their owners to be temporary structures, and were built cheaply in consequence. Unfortunately they survived until September 1 last, when they collapsed with the first shock, and in many cases killed or trapped their unfortunate occupants. In Tokyo the first brick buildings of any importance were put up by the Imperial Government, who were not under the necessity of stinting the cost and were able to obtain competent professional assistance. Nearly all these buildings survived the shock, though a few were unfortunately burned. The main facts of the disaster are probably well known. There was a severe shock of earthquake at 11.57 a.m. on September 1, with further shocks in rapid succession. Many houses fell at once, and fires started; the whole of Yokohama, where a gale of wind was

Fig. 1. General View of Yokohama after Earthquake.

Fig. 2. The Yokohama Specie Bank, Yokohama, in which 700 People lost their Lives by Fire after the Earthquake.*

* The windows and doors of this building had fireproof protection, but the roof had not.

blowing, being burned at once and a large part o Tokyo later in the day.

In Tokyo the initial damage was apparently almost entirely confined to buildings of purely Japanese type. A few shops with weak outer walls of brickwork were partially wrecked, but every substantially built brick structure stood the shocks, and most of them are standing to-day without a crack of any kind in their walls. There are several of these brick buildings of three stories in height, in the neighbourhood of the Tokyo Station. They are well built, with strong, but not unduly thick walls, and with window openings of moderate size. Not one of them has a crack in it, and they appear capable of standing any number of earthquakes. Unfortunately, some of these buildings took fire, and all their woodwork has been destroyed.

The Tokyo Station building, three and four stories in height, and some hundreds of feet long, constructed of red brick, was not damaged by either earthquake or fire. So far as the writer has been able to observe, no station building from Tokyo to Yokohama was wrecked by the earthquake, although many have been damaged by fire. The comparative immunity from damage of the railway structures all through the danger zone is remarkable, and indicates workmanship of a much higher class than the average in Japan. Even where in the same district embankments leading to bridges have been split open and flattened down, the abutments of the bridges themselves have stood apparently uninjured.

Reinforced concrete structures in Tokyo have not come off quite so well as the better-class brick buildings. They have shed much of their brick facing, and apparently there are cracks in the concrete, in some cases, which it may be difficult to repair. They are, however, probably the safest kind of building for the occupants, and office buildings of this class have continued in use without interruption.

The effect on steel frame buildings has been peculiar. A few feet above the ground level, the brickwork is more or less cracked, and this continues for two or three stories. Above the third story and up to the top—some buildings are eight stories high—no damage whatever is to be seen, and most of the buildings, not burned, have continued in use. Where the steel frames have sufficient strength a perfect repair is possible to this type of building. They possess the defect that the brickwork flakes off rather readily from the damaged portions, exposing the bare steel frame, which might be injured by heat. It ought to be possible to remedy this.

At Yokohama all the older brick and wood frame buildings in the former settlement area, fell at once, and unfortunately in many cases killed their occupants, or pinned them down, to be destroyed later by fire, which broke out almost immediately. Some more modern buildings in the same area, which were apparently well constructed, failed also. Excessively large openings for windows or doors uncompensated for by extra thickness of walls, appear to have been the main defect which caused their downfall. In many cases the back walls in which there were smaller openings continued to stand. Greatly to the writer's surprise, he could find no trace of hoop iron bonding in any of the wrecked brick buildings. A moderate amount of such bonding would probably have prevented immediate failure and at least saved the lives of the occupants. The newer brick buildings in Yokohama, several Japanese banks, some municipal buildings, and one building belonging to a British firm, stood the shock without suffering in any way. Unfortunately all but one were afterwards burned out. Most of these buildings are three stories in height, and one has a clock tower twice as high and the brickwork is intact. Little attempt was made to make them fireproof, and one very important building with protected windows had an inflammable roof. In some cases stonework was combined with the brick with very disastrous results, as the stone was almost destroyed by fire and though no failures resulted, the stonework will have to be cut out and replaced. The lessons learned at the San Francisco fire appear to have been entirely ignored in the design of these buildings.

Neither in Tokyo nor Yokohama has the writer been able to find the slightest sign of failure of the foundations of any building, whether wrecked or standing. As the ground floors of most of the office buildings are 4 ft. or 5 ft. above the street level, any cracks in the walls below the ground floor level could be easily seen, but in every case examined the brickwork below the ground floor was intact. Every type of foundation appears to have been equally successful. The foregoing does not apply to buildings which had no foundations whatever.

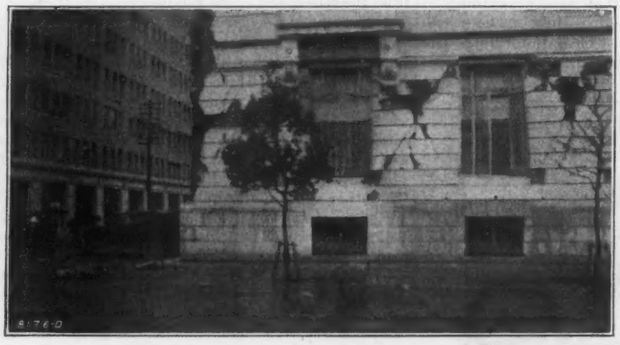


Fig. 3.

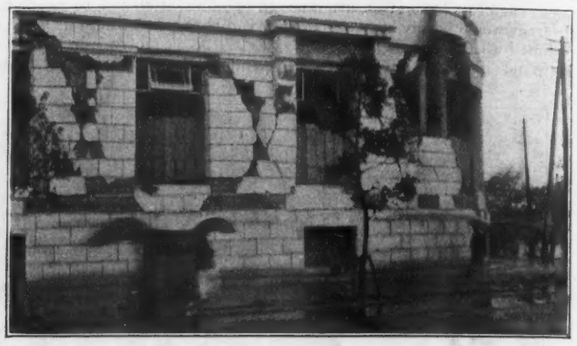


Fig. 4.

Figs. 3 and 4. Views showing Damage to Lower Storeys of Steel Frame Building in Tokio. The Six Upper Storeys were Uninjured.

Fig. 5. Water-street, Yokohama, after Earthquake.

Fig. 6. A Destroyed District in Tokio.

but to all reasonably well-designed structures. There are no signs of any upheaval of solid ground in either city. Made ground which has not been thoroughly consolidated has cracked badly, notably on the Yokohama Bund. Many embankments have subsided and split, but the cracks appear never to extend into solid ground except near the edge of cliffs or on steep hill sides. All through Tokyo, and from there to Yokohama, the abutments of the railway bridges appear to be intact, and miles of retaining walls which hold up the sides of railway cuttings are without a crack in them. Through the heart of the City of Tokyo the railway is supported on brick arches, and these arches survived the shock. There seems no reason for supposing that subways, which would necessarily be founded in solid ground, would be affected in any way by the most severe earthquake. The same would apply to sewers, but the greater parts of Tokyo and Yokohama are

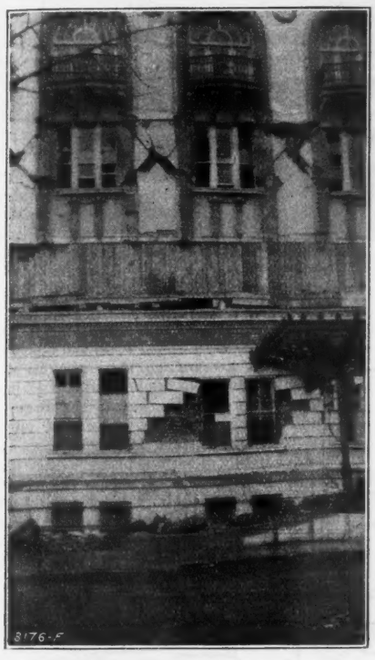


Fig. 7. A Steel Frame Building of which the Weak Frame Buckled, though the Building of Eight Storeys was Saved from Collapse.

so absolutely flat that a gravity system could hardly be successful in either case. A very bad feature of the disaster was the failure of the water supply in certain districts. An official of the waterworks has stated, according to the newspapers, that "it cannot be helped," that in certain places the pipes always have broken and will always continue to break, until flexible pipes are invented! In the writer's opinion it should be helped! and where the railway department can build brick arches that stand, the waterworks engineers ought to be able to get pipes to do the same. If cast-iron pipes laid in loose ground are in the habit of breaking, it is possible that steel pipes laid in solid ground may survive.

To sum up, the writer believes that there need not be the slightest difficulty in reconstructing the two cities of Tokyo and Yokohama, on modern lines, and making all structures earthquake proof, if sufficient money is available. In his opinion, however, the pressing need is not the reconstruction of the comparatively few important buildings destroyed, but the replacement of the hundreds of thousands of homes belonging to the people. If these unfortunates have to wait until fireproof materials are available, they may spend the rest of their lives in tents and similar makeshift structures. It appears as if the necessities of the case must force the rebuilding of most of the homes, of timber, however undesirable that course may be. They can, however, at least be so constructed that they will not collapse on the slightest provocation. On the other side of the Pacific, in Canada and the United States, the Japanese can find examples of wooden houses which will resist any shock, and are weatherproof as well, the latter a merit that no Japanese house possesses.

THE PUBLIC WORKS, ROADS AND TRANSPORT EXHIBITION.

(*Concluded from page* 648.)

One of the features of this exhibition, which closed yesterday, was the prominence of light rollers and rollers of the motor and tandem types. For many reasons the light roller is assuming a more important position in road-making machinery, the chief cause being connected with the adoption of carpeting or top coating. For this work a much lighter machine is considered necessary than is required for consolidating foundations, and as the latter are now frequently made of concrete, the light roller is all that is needed for much of the work. In this class the tandem machine presents advantages as the risk of ridging is obviated with two rolls of similar width in lieu of three. The three-roll machine undoubtedly has advantages, such as the larger diameter of rear rolls, the shorter wheel base and enhanced stability owing to greater width rolled, but these particular points are not so important in carpeting work for which the tandem machine is well suited. Another feature which is essential in this work is a quick reverse, in order to avoid dwelling upon any spot so long as to cause a hollow in the material while still subject to deformation. While steam machines provide this if fitted with lever-reversing gear, in the motor machine, in which a clutch is in any case essential, the reverse is also very easily arranged so as to be effected practically instantaneously. For other reasons the motor roller is attractive; it requires less preparation, there is no cleaning of fires or washing of boilers and so on—in view of which it is not surprising to find this machine gaining in popularity. No less than nine out of 12 firms exhibited motor rollers, while seven showed tandem steam or motor machines.

It is not possible to deal with all the models shown. Some of them are already well known. An interesting new model of light steam roller was shown by Messrs. Wallis and Steevens, Limited, Basingstoke. This machine is known as the "Advance," and it is illustrated in Fig. 21, page 684. It is of 6 tons weight, and has been designed carefully so as to secure specially good and even distribution of the load between the front and rear rollers. The centre of gravity has been kept low; and it is claimed that side rolling has been quite overcome. These features make it possible to employ this machine equally well on consolidating bottom layers, as on finishing top carpeting. A special feature is the arrangement of back axle mounting which enables the rear wheels to adjust themselves automatically to the camber of the road, by which means ridging is avoided. This, of course, is of great importance with fine material and top coatings. The drive and weight distribution at the same time is even over the full width of the tread, and the slip which occurs with coned wheels is obviated. The back axle is divided, and each part is carried in a ball and socket bearing. If desired the automatic action, controlled by a stiff spring, can be cut out, and the axles held, so as to set the wheel treads parallel or at any desired inclination.

Steering is by worm and quadrant as shown, with reducing gear. The gear is all machine-cut. The main pin of the forecarriage head is ball mounted, and steering is easily accomplished. The forecarriage is fitted with a locking arrangement enabling the front fork to be locked for work on straight sections while freedom in all directions can be allowed when working on curves, &c., without throwing any of the bearings of the head out of line. This is secured by fitting the pivot-pin of the steerage with an inverted tee-head, the limbs of which pass into gaps in the fork. Two large pins are passed through both fork casting and tee when the lock is required. The boiler is of the usual locomotive type, and the engine is a double-cylinder one with piston valves. Transmission is by spur gears throughout, two speeds being arranged for, one for rolling and the other for travelling. The drive embodies a differential of machine-cut bevels, enclosed and automatically lubricated. The differential can be locked or unlocked from the footplate.

Large water tanks are fitted, placed so as to affect the relative load distribution as little as possible. The wheels and rolls have cast steel rims with steel plate centres and brass bushed bosses. A screw friction brake operates on the inside of the rims of both the rear rolls, with metal shoes having renewable faces. The fittings include double boiler feed, steam water lifter, water sprayer, and steam cock for heating materials. The machine impresses one as a good piece of workmanship. The firm also exhibit one of their standard 10-ton rollers, as well as a scarifier.

An entirely new design of light tandem roller was to be seen at the stand of Messrs. Sir W. G. Armstrong, Whitworth and Co.,, Limited, Openshaw, Manchester. This is illustrated in Fig. 22, page 684. It is designed to meet the requirements of carpeting work, being quick in action and having divided and independent back and front rolls to facilitate steering. The rolls are 3 ft. 6 in. in diameter for both front and back, the rolling width, in both cases —made up as stated with two rollers—is 4 ft. 6 in. The wheel base has been kept as short as possible, being only 8 ft. 6 in., and a great deal of care has been devoted to secure an exact division of the load between the front and back rolls. The short base and ease of steering greatly facilitate cross rolling. The machine is steam-driven, the boiler being of the locomotive type with Belpaire fire-box, and is designed for burning either coal, coke or wood, having a grate area of 4·14 sq. ft. The working pressure is 180 lb. per square inch. The boiler structure is not in this instance utilised as part of the main framework of the machine, as is so frequently the case in roller design. A main frame of rolled channels is provided, fitted at the front end with a centre ball seating for the front fork, and a saddle on which the fore end of the barrel rests. The swivel gear for the fork allows movement in all directions. The engine which consists of two cylinders, 4¼ in. diameter, by 8 in. stroke, is placed on the top of the boiler and drives by spur gear and chain on to the hind roller. A differential is provided so as to prevent ridging when steering.

A new machine from Messrs. Marshall, Sons and Co., Limited, of Gainsborough, was exhibited in the form of the Millars-Marshall 8-ton spur-geared steam tandem roller. This machine is of the type which is perhaps more familiar in the United States than in this country. As will be seen from the illustrations we give of it in Figs. 23 to 25, page 684, the main features embrace a vertical boiler and an horizontal engine arranged on a very low frame. This roller is specially intended for tar-macadam, asphalt and bituminous surface coatings. The design enables the weight to be very accurately distributed and a very low centre of gravity is secured. The quick reverse which is made such a point of in this class of work is secured by means of a lever gear.

In the size of machine exhibited (four other sizes are actually made at present) the weight in working order is 8¾ tons, the front and back rolls being both 3 ft. 6 in. in diameter, and of a width of 4 ft. 1 in., the rear roll being made up of two widths each 2 ft. 0½ in. The length overall is 15 ft. 2 in. The clearance under the ash pan is 8½ in. The boiler is of the cylindrical vertical multi-tubular type, working at 150 lb. per square inch, and tested hydraulically to 250 lb. The engine runs at 250 r.p.m., at which speed it develops 20 h.p. The two cylinders are cast *en bloc*, and bored at one setting; they are fitted with piston valves placed above the cylinders and both housed in one steam chest. The engine and radial gear is all totally enclosed in an oiltight dustproof cast-iron casing forming part of the engine bed. The radial reverse gear, connecting rods and crossheads are splash lubricated. An oil level plug is provided to facilitate the provision of the correct amount of oil in the well. The crankshaft bearings are ring lubricated. The cranks are placed at right angles and have balance weights. The drive to the front roll is by positive three-shaft transmission,

completely enclosed in detachable casings. The gears are machine cut, comprising two pinions and two spur wheels. The front roll revolves on a dead axle carried in blocks on the channel side frames. The roll rim and hub are of cast-iron in the larger sizes and are renewable as to rims. The rear rolls revolve independently on the axle carried by the fork, which is of cast steel. The king post is a steel forging. The king post and fork are connected with a heavy swivel pin allowing ample rocking movement, while the locking angle is 35 deg., so that the roller can be employed in confined spaces.

The steering gear consists of a steel plate quadrant keyed to the king post, with a cast-iron worm sector bolted to it. The sector is operated by a worm on a transverse shaft, and is provided with hand or power control, or a combination of both. Power control is obtained with a small three-cylinder single-acting auxiliary engine coupled to the worm spindle by roller chain and sprockets. It is quick in operation and is said to be a great advantage when rolling short diagonal or zig-zag courses. The steering engine cuts out automatically so as to prevent over-locking.

The main frame is of steel channel and boiler plating. The trailing end is built up of plating and angles, carried backwards and upwards and terminating in the steerage casting. The side view in Fig. 23, on page 684, shows the rear end and the engine arranged on the main frame. A coal bunker for 3 cwt. of fuel is placed over the front roll, and beyond the latter, above and between the frames, is a water tank of 115 gallons capacity, which normally suffices for 5 hours' work. A brake operated by hand screw acts on a drum on the driving roll, on the side opposite to the engine drive. The blocks are lined with Ferodo, and work in grooves. At the front end is arranged a strong headstock and eye, while a stout shackle is fitted to the swivel pin of the fork.

Messrs. Marshall's other exhibits included an 8-ton standard "Marshall" road roller with compound engine and piston valve gear and locomotive boiler for 180 lb. pressure, with corrugated tube plate, &c. The firm also exhibited a compound steam tractor intended for light haulage work. The boiler of this is for 200 lb. pressure, and it is fitted with the firm's patent fire-box and corrugated smoke-box tube plate. The standard speeds are 2¼ m.p.h. and 5 m.p.h.

The exhibit of Messrs. Ruston and Hornsby, Limited, Lincoln, included a crane navvy convertible to a drag line machine or grab crane, which we need not refer to at length on the present occasion as it was fully described in the paper read by Mr. W. Barnes before the British Association in Liverpool last September and reproduced in our columns in our issue of October 12, page 473. A new model of tandem motor road roller was also shown. This we illustrate in Figs. 26 to 31, on this and the opposite pages. In 1921 (vol. cxii, page 759) we illustrated the firms' three-wheel roller. The tandem arrangement has necessitated considerable modification of the structural arrangement though the power unit and transmission are on the same lines as before.

The rollers of the tandem machine are 3 ft. and 3 ft. 6 in. in diameter, the wheel base being 10 ft. 3 in. The machine is driven by a two-cylinder vertical paraffin engine, fitted with high-tension magneto, governor and circulating pump. Petrol is used for starting. The drive is taken from the engine to a gear-box by way of flexible couplings, the gear-box being provided with two clutches which are shown in detail in Figs. 29 to 31. The gear-box provides three speeds. The clutch lever is the vertical one shown in Fig. 30, and the manner in which the drive is controlled by it will be clear from the plan in Fig. 31. Power is transmitted through either one or the other of the bevels, whichever clutch is engaged to give forward or reverse, as required, to a pinion on the centre line of the gear. This drives a large spur on a shaft extending across the main frame, at the end of which is a gear driving the rear roller by outside chain. Steering is by chain, the drums being worked by worm and worm wheel, totally enclosed and running in an oil bath, as shown in Fig. 30. This illustration also shows the foot brake operating on to the inside of the rim of the flywheel. The latter has a rim finished for use with a belt for driving independent machines, if desired. A large tank for cooling water is placed at the rear at the back of the rear roller. Water ballast may also be used in the rear roller so that the weight may be adjusted as desired. In addition to the foot brake referred to above, a hand brake working by means of a band on the rear roller, is also provided. The engine is started by means of a handle at the back of the machine on the near side of the rear roller.

At the stand of Messrs. Robey and Co., Limited, Lincoln, one of the firm's 7-ton tandem steam rollers was to be seen. This machine we illustrated when it was introduced about a year ago.* The design is characterised by the use of the firm's stayless boiler and inclined rolled channel side frames, with chain drive to the back roller, the boiler and engine unit being similar to that of the company's steam wagon.

Other rollers were shown by Messrs. John Fowler and Co. (Leeds), Limited, the most conspicuous of which was a motor three-wheel roller with deep slab framing, having three speeds forward and reverse. This machine has a four-cylinder vertical engine, working normally on petrol or benzol, but a special vaporiser can be fitted for paraffin. High-tension ignition is adopted and water circulation by pump. The radiator is provided with a fan. The engine horse-power is 35 for the 10-ton size, and the

* Engineering, vol. cxiii, page 681.

MOTOR ROLLER AT THE PUBLIC WORKS EXHIBITION.

CONSTRUCTED BY MESSRS. RUSTON AND HORNSBY, LIMITED, ENGINEERS, LINCOLN.

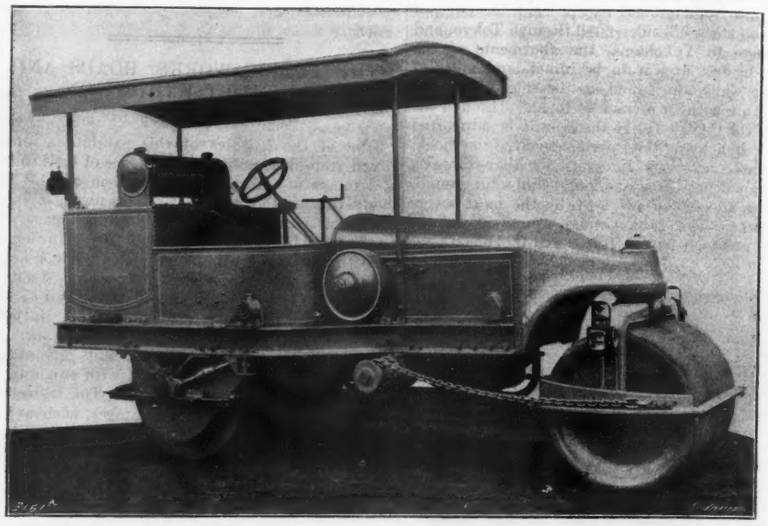


Fig. 26.

Fig. 27.

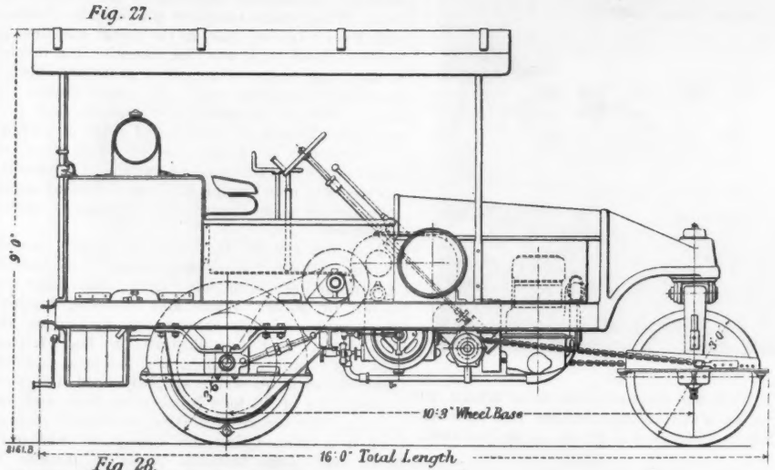
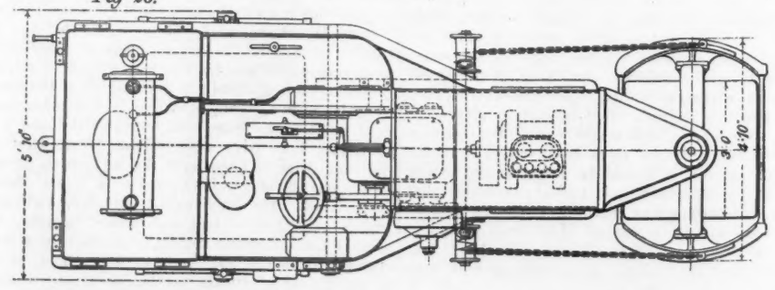


Fig 28.



DETAILS OF MOTOR ROLLER AT THE PUBLIC WORKS EXHIBITION.

CONSTRUCTED BY MESSRS. RUSTON AND HORNSBY, LIMITED, ENGINEERS, LINCOLN.

Fig. 29.

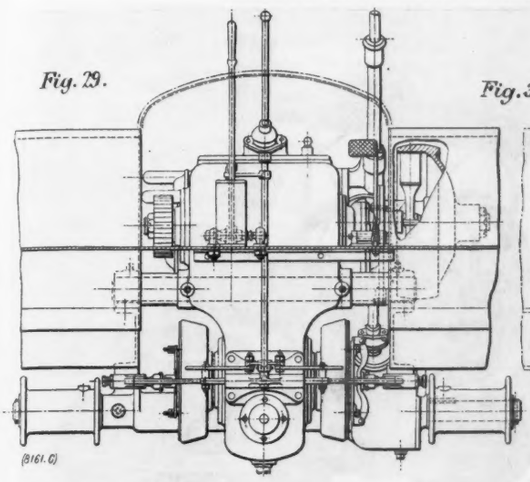
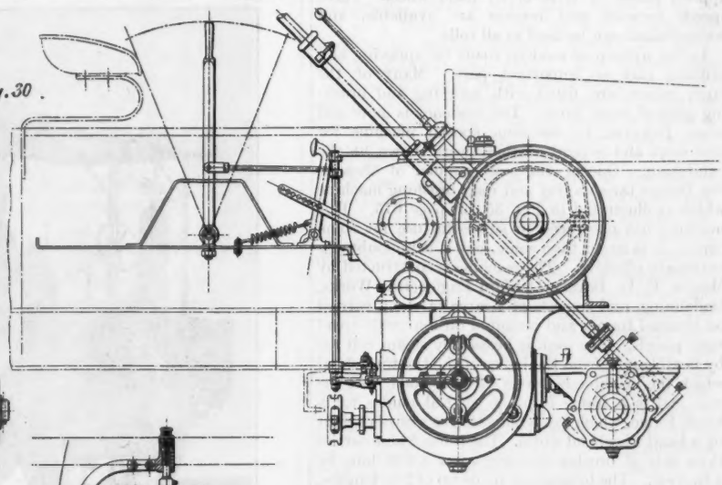


Fig. 30.



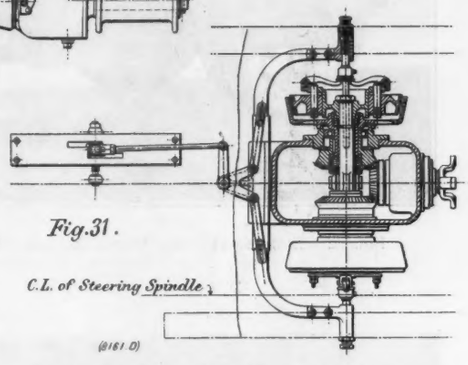


Fig. 31.

C.L. of Steering Spindle

revolutions per minute 1,000. The front rolls are 3 ft. 9 in. in diameter and together of 4 ft. 1 in. width. The back rollers are 5 ft. 3 in. diameter and of 1 ft. 6 in. width, the total width rolled being 6 ft. 3 in. All are arranged for water ballast. The frame is of rolled sections and deep steel plates. The clutch is of the flat plate type lined with Ferodo. The three speeds range between 1½ m.p.h. and 3½ m.p.h., and are available both for forward and reverse, the reversing gear being of the epicyclic type. The front rollers are fitted in a swivelling fork on ball bearings and spring mounted. The gear-box is also fitted with roller bearings. Messrs. Fowler also showed a steam roller as well as their latest type of convertible steam tractor and roller which can be rapidly converted from one use to the other. As a tractor this machine complies with the Light Locomotives Act; all wheels are fitted with solid rubber tyres. In a couple of hours the change to an 8-ton roller can be made, by the driver assisted by one man, with the need of a jack only for the hind wheels.

Messrs. Thomas Green and Son, Limited, Smithfield Ironworks, Leeds, showed two machines, one a 10-ton compound steam roller and the other a 7½-ton motor tandem roller. The latter had rolled steel channel frames brought in at the front to take the forecarriage casting. A Dorman engine is mounted in this design across the frame just behind the forecarriage, driving a chain sprocket through a single reduction gear from the gear-box. The drive to the back roller is by roller chain. The back axle is carried in bearings in horn cheeks, and is spring mounted. A large water tank is carried over the rear roller.

Messrs. Barford and Perkins, Limited, Peterborough, showed several of their well-known motor machines. One of these was the three-wheel water ballast roller which we illustrated and described in our issue of December 30, 1921 (page 884). A new model to be shown for the first time was a machine known as the firm's FS8 type. This is a tandem machine with rollers 4 ft. wide. The front roll is double. The frames are of 6 in. by 3 in. channel section and the engine and gear-box unit is mounted transversely on the frame. The drive from the gear-box is taken through a wide toothed reduction train to a cross-shaft which, on the near side of the machine, drives by chain and sprockets to the back roll. The back roller bearings are carried in spring-mounted axle boxes, and fitted with radius bars. The front head is also spring mounted. Two speeds are provided both for forward gear and reverse, and two brakes, one a band-brake fitted on the main drive cross-shaft, and the other a band-brake working on a drum on the offside of the rear roller. The engine has four cylinders, works on paraffin, and develops 28 b.h.p. at 1,000 r.p.m. It is made by the Albion Motor Car Company, and is similar to that fitted to their War Office subsidy lorry. The clutch is of the plate type. The machine weighs 8 tons. A 140 gallon large water-sprinkling tank is fitted behind.

In contrast with the type of motor roller with small high-speed engine and channel frames were to be seen one or two examples of deep slab frames mounted with slow-speed horizontal-type engines. One such, by Messrs. Aveling and Porter, Limited, Rochester, is shown in Fig. 32, page 674. This machine approaches to the steam prototype much more closely than most. The roller is of the three-wheel type. Above the deep vertical frames of plates and rolled sections, is mounted a single cylinder Blackstone engine suitable for any fuel from petrol to crude oil. Two heavy large diameter flywheels are fitted. The machine has two speeds forward and two for reverse, the change of direction being by clutch. The drive is by gear throughout. The crank and engine gear is totally enclosed. A compressed air bottle is fitted for starting. The drivers' footplate is arranged in the position usual with steam rollers, while an exhaust uptake is provided in the position and closely resembling the conventional chimney. The front fork is a very light ribbed steel casting. The firm also showed a compound steam roller.

A machine on somewhat similar lines to the foregoing was shown by Messrs. Clayton and Shuttleworth, Limited, Lincoln. This was a 12-ton roller driven by a single-cylinder crude oil engine of the hot bulb type, started with a lamp or air bottle, and working on the two-cycle principle. A single flywheel is fitted and a centrifugal spring-loaded governor. The main frame is of heavy rolled steel sections, with cross-members of channel with end strips welded on and afterwards machined. The horn plates have steel strips welded on and afterwards machined. The engine is mounted direct on the main frame. At the front end the frame ends in a roller head of cast iron and the silencer is arranged at this end of the machine in communication with a chimney type uptake. The front fork and stem are one casting. The gears provide two speeds forward (1½ m.p.h. and 3½ m.p.h.) and one reverse. One brake operates by hand wheel on the hind axle and a second on the second motion shaft, by lever; either is sufficient to hold the machine on a steep gradient. The foot-plate is of ample size and allows the driver plenty of room for attending to the controls. A fuel tank is carried at the rear, and underneath at this end is a large cooling water tank.

The roller exhibited by the Builders and Contractors Plant, Limited, 51, Tothill-street, S.W.1, is a departure from all conventional design. The machine shown was a 2-ton model only, though larger patterns are built. The 2-ton model has an overall length of 14 ft., and width of 4 ft. 6 in. It is fitted with a 4½-h.p. engine. It is illustrated in Fig. 33, page 674, and has one large roller, 4 ft. 6 in. in diameter and 4 ft. wide, and one small swivelling roller 2 ft. in diameter and 2 ft. wide. The framing is of rolled steel sections. The engine is hung inside the large roller. It is of the vertical high-speed petrol type with pump circulation, and is fitted with sun and planet gears, the pinion of which works on the same axis as the roller and transmits the drive to a sprocket outside carried by the main frame on the near side of the machine. This sprocket transmits the drive by chain to a cross-shaft just behind the main roller, and at the other end of this is a bevel reversing clutch and two-speed gear, driving another longitudinal shaft from which the larger roller is driven by worm. The fuel and oil tanks are carried inside the roller on the engine mounting. A 60-gallon circulating and sprinkling tank is arranged at the front end, connected with the engine water jacket by means of piping passing through the roller axis on the off-side of the machine. A "reaper" type seat is provided, and all controls are brought back to this. Steering is by hand wheel, and worm and worm wheel, which controls the small swivelling back roller. This consists of two rolls so that dragging of the surface is avoided. This roller swivels on a ball bearing. The machine can turn in little more than its own length. The clutch is of the expanding ring metal-to-metal type.

Another small motor (4 tons 15 cwt.), which is a departure from usual practice, is shown by the Chaseside Motor Company, Limited, Chase Side, Enfield. This machine is illustrated in Fig. 34, page 674, and the main component will be recognised as a Fordson tractor unit. In fact, a tractor of this pattern is easily convertible into a roller at very small cost. The front roller has a track of 3 ft. 7 in., made up of two rolls. The back rollers give a total track width of 5 ft. 8 in. The wheel base is 7 ft. 1 in., and the length overall slightly more than 10 ft. The front roller is carried in a nearly horizontal fork, which is pivoted under the radiator and is provided with a long tail extending back to behind the rear axle. Here steering is effected by

means of chain controlled by the large hand wheel on the vertical shaft shown. Band brakes are furnished to each part of the back axle and can be applied either by lever or by hand wheel. Three speeds forward and reverse are available, and water ballast can be used in all rolls.

In the upkeep of modern roads tar-spraying and gritting play an important part. Many of the large rollers are fitted with spraying and brushing gear of some form. The tendency is more and more, however, to use some special machine for this work and several of these were shown at the exhibition. One of the most popular of these is the Barnes tar-spraying and road brushing machine which is illustrated in Fig. 35, on page 675. This machine has now been in successful use for some time. It is larger than some, but it is undoubtedly extremely effective. The machine is constructed by Messrs. F. G. Barnes, Ockford Engineering Works, Godalming, and consists of a large tar tank carried on channel frames and mounted on four wide-tread road wheels. The tank is heated by steam coil fed by flexible pipe from the boiler of the tractor behind which the machine is drawn over the road. At the rear end is a frame forming vertical guides for a brush frame, which can be adjusted as regards height by a hand wheel and worm. The brush frame carries three sets of brushes covering an area 6 ft. long by 5 ft. wide. The brushes are made up of 2 ft. lengths, and are mounted on springs. They can adjust themselves to the camber, while pressure can be applied by lowering the frame. Mounted on this frame above the brushes is an horizontal longitudinal shaft with three crank throws, spaced apart. The latter, by means of connecting rods, are coupled to the brushes, which are caused to move in guides to and fro' across the road as the whole travels forward. The crank is rotated by bevels and chain and sprocket drive taken off the rear axle, on which a clutch is provided. The heated tar is fed in front of the brushes by gravity from a spray pipe which is made to oscillate sideways so that the tar is well distributed. Different widths can be treated by means of plungers in the spray pipe. The oscillation of the spray and the following brushes, spreads the tar very evenly over the surface and ensures covering every spot. The tanks are made to contain up to 1,000 gallons, and being steam heated all risk of fire is avoided. The machine will tar at a steady rate of about 2 m.p.h. A 1,000-gallon tank can be heated to 200 deg. F. in 3½ hours. The quantity of tar used is adjustable. A simple winch and cradle are fitted for working tar barrels up a ramp to the top of the tank.

A much lighter machine of the horse-drawn variety was exhibited in the Coleman "Flapper" tar sprayer. This was fully illustrated recently in ENGINEERING,* and we need not therefore deal with it at length. The principle on which the machine works is unusual in that brushes are not employed, the tar being beaten down in the form of a spray, on to the road surface, by rapidly revolving blades. It is constructed by Messrs. Thomas Coleman and Sons, Limited, Alfreton-road, Derby.

A bitumen sprayer was exhibited by Messrs. Builders and Contractors Plant, Ltd., 51, Tothill-street, S.W. 1, provided with an oil burner in order to secure the high temperature required for bitumen, and an engine-driven pump for forcing the fluid material through the spray pipe fitted with ten jets. This plant is fitted up as a portable (trailer). A neat barrel hoist is arranged for lifting the barrels from ground level to the top of the tank.

A large 1,000-gallon tar-spraying machine was shown by Messrs. W. and J. Glossop, Hipperholme, Halifax. The vehicle in this case is an Atkinson 6-ton steamer, on the chassis of which is placed the large steam-heated tar tank. Arranged across the frame to the rear of this is a horizontal duplex steam pump delivering to two sprayers which provide a row of altogether 10 jets across the track. The sprayers are shrouded with a metal hood, and are hinged so that the height from the ground can be easily adjusted. The pump can be used for filling the tank. The vehicle is a self-contained unit and is as easily handled and manœuvred as the ordinary lorry. The tar pipes can be cleared by hot gases or steam. The firm also exhibited a bitumen sprayer

* See page 142, *ante*.

MOTOR ROLLERS AT THE PUBLIC WORKS EXHIBITION.

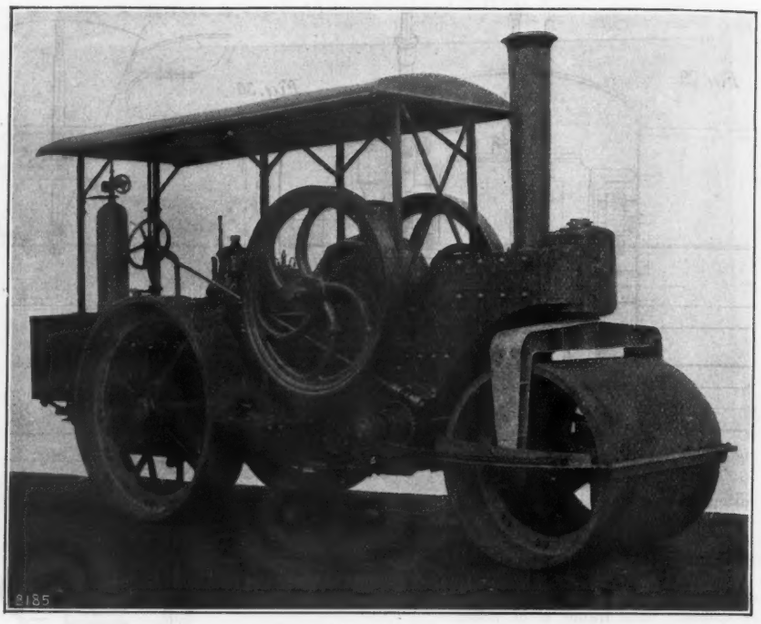


FIG. 32. SINGLE-CYLINDER MOTOR ROLLER; MESSRS. AVELING AND PORTER, LIMITED, ROCHESTER.

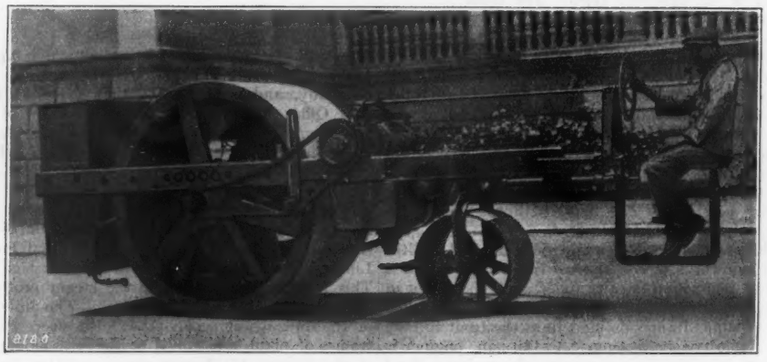


FIG. 33. 2-TON MOTOR ROLLER; MESSRS. BUILDERS AND CONTRACTORS PLANT, LIMITED, LONDON.

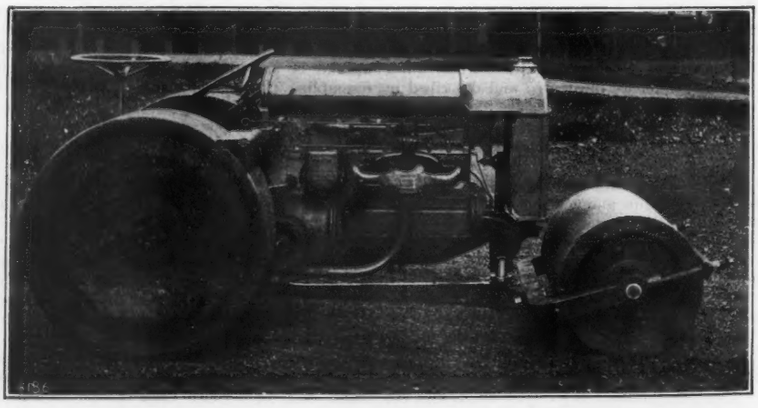


FIG. 34. 4-TON MOTOR ROLLER; THE CHASESIDE MOTOR COMPANY, LIMITED, ENFIELD.

MACHINERY AT THE PUBLIC WORKS EXHIBITION.

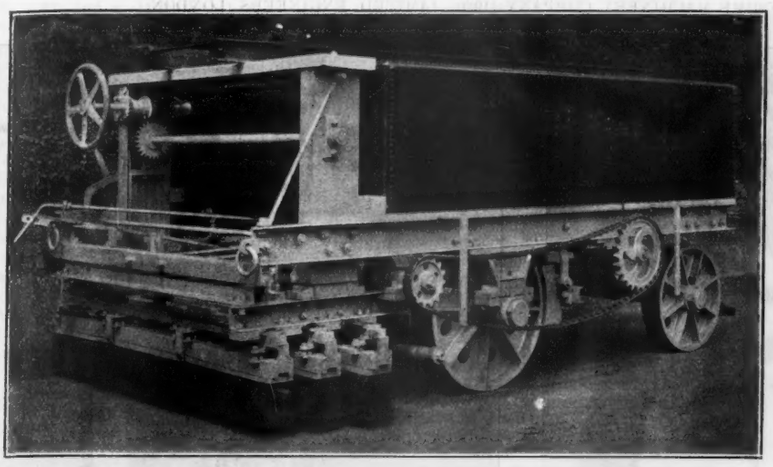


FIG. 35. TAR-SPRAYING AND BRUSHING MACHINE; MESSRS. F. G. BARNES, GODALMING.

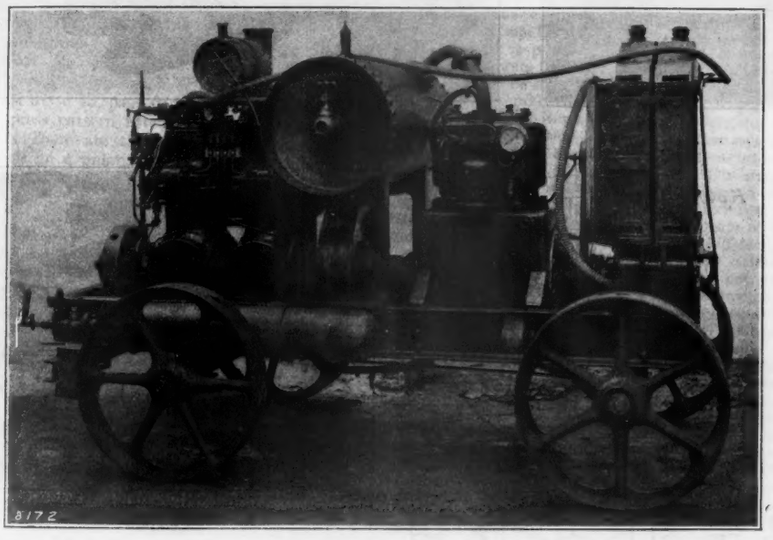


FIG. 36. 120-CUB. FT. PORTABLE COMPRESSOR SET; MESSRS. BROOM AND WADE, LIMITED, HIGH WYCOMBE.

in which hot compressed air is employed for the spray, the bitumen being heated either by hot compressed air, or direct. The pipe system in this case is cleared by hot compressed air.

Messrs. Bristowe's Machines, Limited, St. Stephen's House, Victoria Embankment, S.W. 1, showed a horse-drawn hand tar sprayer with double-acting ball valve pump. This machine was of 200 gallons capacity, coal-fired. The cold material is poured on to a perforated trough inside the boiler, and as it is heated passes through into the main portion of the body from which it is drawn at a point near the furnace by a strainer-fitted pump. From the pump the tar is forced through a filter, passing then to a long flexible hand-spraying pipe terminating in a ball jet. A by-pass is fitted so that hot air can be drawn from the boiler instead of tar, and pumped through the system to warm it up before, or clear it out after, use. A thermometer is provided in the tar pipe close to the pump. The firm have a similar but rather simplified machine for use with bitumen. The Phœnix Engineering Company, Limited, of Chard, Somerset, and Messrs. W. Weeks and Son, Limited, Maidstone, and other firms, also showed hand-pump sprayers of various patterns.

In conjunction with tar spraying, gritting has to be arranged for, and many attempts have been made to perform this satisfactorily by machine. Gritting, of course, is often required also alone, for surface treating the roads in bad weather. A combined tarring and gritting machine of large capacity was shown by Messrs. Aveling and Porter, Limited, arranged as a trailer to be drawn behind a steam roller. This unit is provided with a sweeper brush. The tar tank is of 270 gallons capacity, heated by a large coil with steam from the engine boiler. The tar is maintained at 350 deg. F. A positive acting pump forces the tar to the sprayer pipe at a pressure of 200 lb. per square inch. There are eight nozzles divided into pairs, and any pair may be cut out or operated independently. Each pair covers a width of 18 in. The gritter part of the machine consists of a 2¼ cub. yard hopper of a width to distribute over 6 ft. (the width of road tarred). The width is divided into four sections corresponding with the sprayers, and any section or sections can be cut out to correspond with the jets used. Near the gate or bottom opening of the hopper, a shaft with small twisted paddles is made to revolve with the object of keeping the grit agitated in order to ensure a flow through the gate.

At the stand of Messrs. F. Walters and Co., Rugby, a Simplex gritting machine was shown. This little machine was fully illustrated recently in ENGINEERING (page 143 *ante*). The hopper is provided with a revolving disc which serves to distribute the grit over a wide or narrow track as desired. A small hand gritter somewhat resembling a barrow hopper was shown by Messrs. Wallis and Steevens, Limited, Basingstoke, while a novel little appliance to be used as a trailer, or drawn by man power, was exhibited by Messrs. Thomas Coleman and Sons, Limited, Alfreton-road, Derby. This machine has a rectangular hopper carried on an angle-iron frame, mounted on four wheels. The hopper is hinged in front, and at the back on the frame is placed a triangular support carrying a small hand winch, lifting the rear end of the hopper by cable. On one of the rear wheels a disc is fixed to the spokes on the inside, and projecting from this are six pegs. As the wheels revolve these pegs hit a striking rod coupled with a crank at the front end of the hopper, and this crank transfers the movement of the striking rod to a bar set inside and across the hopper mouth. The latter bar has short and long fingers on it, and these as they move to and fro' agitate the grit and encourage it to run out of the adjustable gate opening on to a chute board and thence on to the road clear of the front wheels. The striking bar referred to above is fitted with a pendulum, and when struck by the wheel peg in one direction is sharply returned by the pendulum weight to its original position. The jerky motion thus imparted to the fingers greatly assists the flow of the grit. As the hopper empties, it is tilted up at the back. The rectangular hopper has the advantage of providing a considerable capacity on a machine of small size.

For small repair work a portable heater may often prove of service on tar macadam or bituminous carpet work. At least two outfits intended for such work were exhibited. One was shown by Messrs. Thomas Coleman, Alfreton-road, Derby, and consisted of a small furnace mounted on wheels and fitted with a little fan of the type often used on portable smith's forges. The hot gases of combustion driven from the furnace pass out either through a smoke stack or are deflected downwards into a rectangular hood which is placed over the patch to be heated, escaping under the edge.

The outfit shown by Messrs. Builders and Contractors Plants, Limited, 51, Tothill-street, S.W. 1, is of the primus burner or oil flare variety. On a set of small wheels an air and oil tank working at 4 atmospheres is fitted. The burner can be used without a hood for steel repair work of a general nature. For patching work a hood is added, provided internally with deflecting bars so as to spread the flame well out under the hood which is placed over the patch. Messrs. Millars' Timber and Trading Company, Limited, Pinners' Hall, E.C. 2, also showed an oil flame patch heater of a larger scale, and Messrs. A. C. Wells and Co., 102, Midland-road, N.W. 1, exhibited their patch driers with Wells burners.

The use of compressed air tools is now so general that interest attaches to exhibits of compressing plant, &c. At the exhibition Messrs. Brown and Wade made a large display of these machines, other interesting exhibits being staged by Messrs. Reavell and Co., Limited, Ipswich, and the Ingersoll-Rand Company, 165, Queen Victoria-street, E.C. 4. Portable sets were conspicuous in these, suitable for use in connection with breaking up concrete foundations by pneumatic picks. One such unit is illustrated in Fig. 36, annexed, this being a portable set by Messrs. Broom and Wade, Limited, of High Wycombe. This set is designed to deliver 120 cub. ft. of free air per minute at 100 lb. pressure, and is guaranteed to do this at a fuel cost of 6s. per 8-hour day, which is less than one-sixth the cost of running a petrol plant at current prices. The compressor is a double cylinder machine with cylinders 7 in. diameter by 5½ in. stroke. It is driven direct by a crude oil Petter engine of 24–28 b.h.p., running at 525 r.p.m., and fitted with the Petter cold-starting arrangement. Both engine and compressor are designed for the speed at which they run and are not merely just convenient sizes assembled in one unit. The equipment of the set includes twin radiators, circulating pump, fan, air receiver, &c.

The miscellaneous plant and many other interesting exhibits on which lack of space forbids us to enlarge at the moment, included oil engines by various well-known makers, pumps by Messrs.

CONCRETE BLOCK-MAKING PRESS AT THE PUBLIC WORKS EXHIBITION.

CONSTRUCTED BY MESSRS. RANSOME MACHINERY COMPANY (1920), LIMITED, ENGINEERS, LONDON.

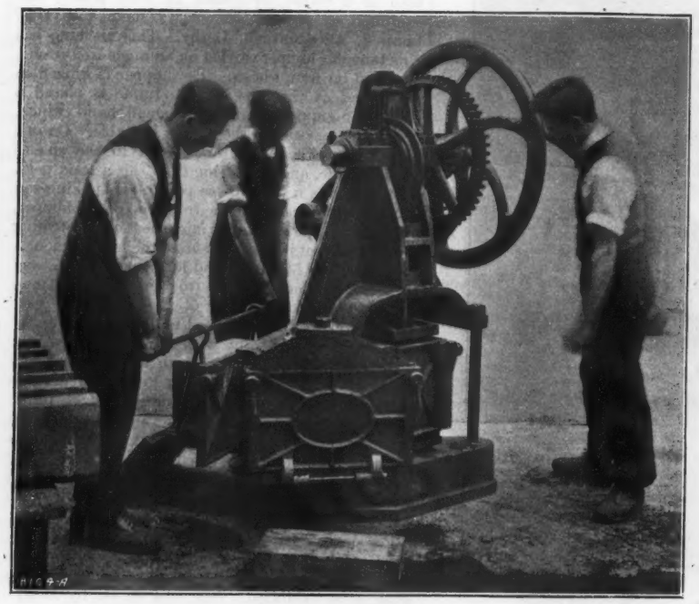
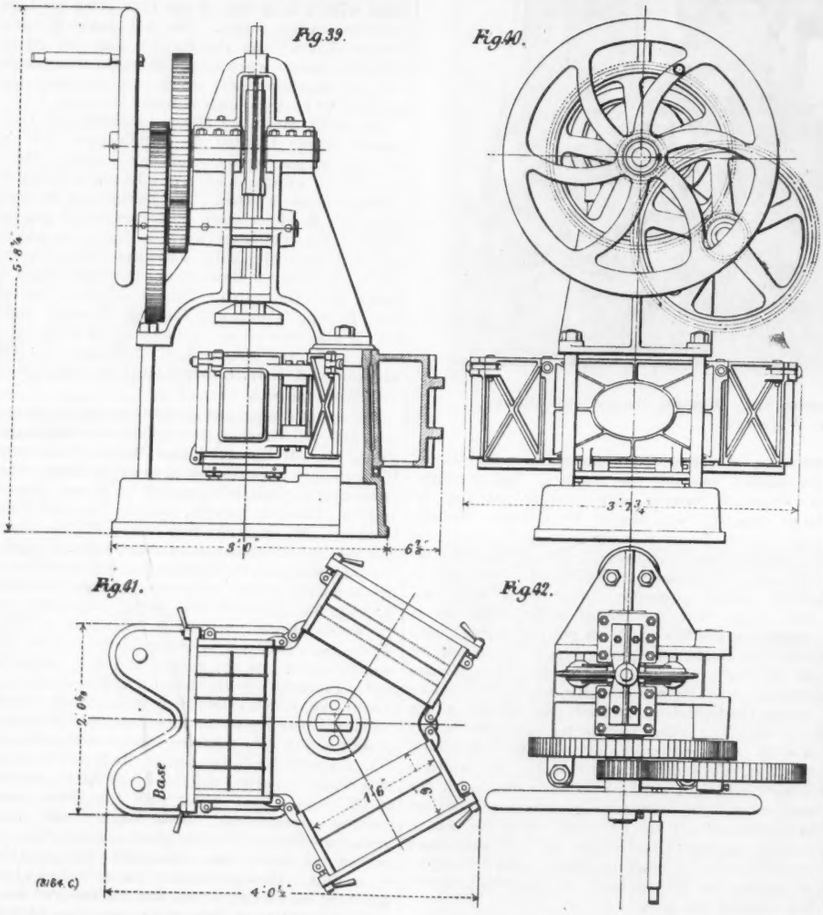


FIG. 37.

FIG. 38.



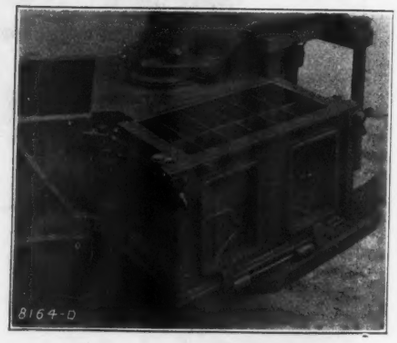


FIG. 43.

Tangyes, Limited, and others, meters by Messrs. Beck and Co., 130, Great Suffolk-street, S.E., Messrs. Wilson and Perrett, Limited, Fairfield-street, Wandsworth, Messrs. Geo. Kent, Limited, 199, High Holborn, W.C., &c. Messrs. W. and T. Avery, Limited, exhibited the Aveling and Avery "Axle-weight ascertainer," consisting of two portable weighing machines, each taking up to 8 tons, or together an axle load of 16 tons.

Engineers are familiar over here with the system now known as "thrust-boring," by which pipes of a moderate and small diameter can be laid underground without trenching. The system consists in forcing a bar and head through the subsoil in the direction desired, the passage being made by displacing the material of the strata, and not by excavating it. Only a pit is needed, with a firm back to give an abutment. A system of this kind worked out rather differently from that with which we are most familiar in this country, has been in use for some time in America where the appliance used is an adaptation of the lifting jack. One of these machines was shown at the stand of Messrs. George Hatch, Limited, Queenhithe, Upper Thames-street. The appliance is one of the well-known Barrett jack gears mounted and travelling on a base on which is a length of ratchet-toothed rack. The length of movement of the head is 7 ft. 6 in. The moving head is fitted to take couplings for all sizes of pipe from ¾ in. to 4 in., the latter being the maximum size of the pipe which can be driven. A "pilot" is fitted to the pipe. For very loose soil this may be a solid pointed head, for harder soils a short tubular pilot is used, slightly larger than the pipe to be driven. When a trench has been dug the jack is laid in it with one end against an abutment timber. The pipe is placed in

position and aligned in the desired direction and the jack ratcheted so as to force the pipe into the soil. A 7-ft. 6-in. length of pipe is first used and then withdrawn and a 14-ft. length then put in and forced; the short length is then added and forced in, and withdrawn, and a long length then pressed in. This continues until the distance has been traversed. Small obstructions are pressed aside, but if large ones are encountered another spot must be tried. Sometimes in these systems the pipe becomes deflected, but the record of successful work is a very excellent one indeed, and the system has proved highly economical in numberless instances. Lengths up to 300 ft. have been accomplished.

One of the miscellaneous exhibits worthy of mention is the Powrcleer apparatus for cleaning incrusted water mains. This machine was shown by Messrs. W. and J. Glossop, Halifax. The machine is power driven. In use a trench is cut, the pipe broken and the machine frame clamped to the pipe end. On the frame is a travelling petrol engine unit driving a revolving cutter bar and head. The latter is entered in the pipe, and the engine and bar are then worked forward by a small hand rope winch at the front end of the frame. When the frame end is reached the cutter is uncoupled and the engine traversed back to the far end again, a length of bar is added behind the cutter and the process repeated. This machine has been in use for some while and has accomplished a great deal of successful work.

Rather out of the normal run of the exhibition perhaps, but decidedly interesting, was the exhibit of the block moulding machine shown by Messrs. Ransome Machinery Company (1920), Limited, 14, Grosvenor Gardens, S.W. 1. This we illustrate in Figs. 37 to 43, page 676. The machine is of the hand press pattern fitted with revolving moulding boxes. There are three boxes, revolving on ball bearings on a pillar, the largest sized block which the machine is capable of making being 18 in. by 9 in. by 9 in. The press consists of reduction gears working a shaft on which is an eccentric. The eccentric is fitted with a roller ring and revolves inside a strap, within which it is allowed freedom of movement on the slider crank principle. The strap is connected, by three plungers working in guides, with the upper plate of the press. The whole gear is capable of exerting a pressure of about 40 tons on the concrete in the mould. In use three hands, a charge hand and two youths, can keep the machine fully occupied. The boxes are used in rotation, and filling and pressing is carried on while others are being prepared and filled. After filling and striking off, a wooden block is placed on the concrete in the mould and it is swung under the ram. A few turns of the wheel brings the ram down on to the block and lifts it again. The ram never enters the mould, but the concrete is compressed about 25 per cent. The block is lifted, the catches on the box released, and the block removed on its pallet. Different-sized blocks, tiles, &c., can be pressed by using division plates as shown in Fig. 43, while by the use of wooden patterns all sorts of moulded faces can be given to the blocks. The concrete used is a semi-dry mixture, and the blocks are so firm that there is no risk on removing them from the pallets after 24 hours. The machine is a development of one invented by Mr. Wm. Marriott, M.Inst.C.E., engineer traffic manager of the Midland and Great Northern Railway, who is well known as an advocate of, and authority on, concrete work. It is adaptable to a very wide range of products.

The Institution of Structural Engineers.—We are informed that on and after December 1, the address of the Institution of Structural Engineers will be Abbey House, 2–8, Victoria-street, S.W. 1, instead of as hitherto, Denison House, 296, Vauxhall Bridge-road, S.W. 1.

Visit to Works of the Coventry Chain Company, Limited.—By the courtesy of the directors of the above company, the members of the Leamington and Warwick Engineering Society were recently given the opportunity of inspecting these works, and seeing the manufacture of driving chains ranging from those suitable for magneto-driving up to the largest examples of silent chain. Other specialities of the company, such as free-wheels and sprocket-wheels, were also examined in course of manufacture. The output by the Coventry Chain Company of cycle chains alone is so great that every week the component parts turned out run into millions. The party was conducted through the factory by Mr. H. Sinnott, the works manager.

THE PUBLIC WORKS, ROADS AND TRANSPORT CONGRESS.

A series of conferences arranged by various different bodies formed a part of the programme of the Public Works, Roads and Transport Congress which was concluded yesterday at the Royal Agricultural Hall, Islington, London, N. With the exhibition held in connection with this congress we commenced to deal on page 644 *ante*, and we conclude our description of the principal exhibits on page 671 of this issue. We now propose to deal briefly with some of the papers read at the conferences, but owing to the demands upon our space, it will be necessary to select only those which appear likely to be of interest to the majority of our readers.

Rivers Pollution.

The proceedings commenced on Thursday, the 22nd instant, the programme for that day being arranged by the Association of Managers of Sewage Disposal Works. At the morning meeting, held under the chairmanship of Dr. Maclean Wilson, the first paper taken was one by Mr. C. Jepson entitled "Rivers Pollution." In this the author first dealt with the historical and legal aspects of the question, stating that the effect of the legislative measures enacted had been very materially to improve the conditions of the rivers, although improved methods of dealing with sewage and trade effluents, together with an increased realisation of the importance of the subject, had largely contributed to this result. In the author's opinion, the chief cause of river pollution was the trade waste of the manufacturer. He pointed out that about half the manufacturers in the country discharged their effluents into the sewers, and that, excepting those who signed an agreement with respect to preliminary treatment, such manufacturers were free from any further responsibility with respect to its effective purification. If manufacturers failed to produce an effluent satisfactory to the Rivers Authorities, it was possible, however, for the latter to take legal action, although they were seriously hampered by saving clauses and restrictions inserted in the various Acts of Parliament which became a weapon in the hands of those who desired to avoid their responsibilities. The degree of control exercised by Rivers Authorities varied in different parts of the country, and this was the cause of dissatisfaction. There was a difficulty in fixing an equitable standard for application to all classes of trade waste, but, as a general rule, the author suggested that waste liquors should not be allowed to contain excessive suspended matter, highly putrescible matter, readily oxidisable matter such as sulphides, &c., material acidity or alkalinity, or sterilising agents such as free chlorine. To fix a standard for sewer effluents, he said, was a much simpler matter, and that adopted by the Royal Commission on Sewage Disposal was generally accepted as equitable, although it had not been adopted by any Rivers Authority. In the final section of the paper, relating to future requirements with respect to rivers pollution, the author summarised the recommendations contained in the third report of the Royal Commission on Sewage Disposal, issued some 20 years ago, and expressed the view that, in addition to these, provision should be made to guard against inadequate control or wilful neglect of purification plants by the imposition of suitable penalties. Local authorities, he said, should also be given power to prohibit the discharge into the sewers of any waste material which would give rise to conditions dangerous to the life or health of workmen engaged in the sewers or which would so alter the character of the sewage as to disorganise any practicable type of sewage purification plant or create a serious nuisance. He also advocated the institution of a research laboratory under the control of a central body to investigate questions arising in connection with rivers pollution.

Sewage Works Analyses and Standards of Purification.

The second paper read at the morning meeting was by Mr. J. H. Garner and took the form of a plea for greater uniformity in sewage works analyses and standards of purification. In this, the author, after reviewing the anomalies of existing standards of purification, expressed the view that those recommended by the Royal Commission covering both sewage and trade effluents should be given a fair trial extending over a definite number of years and once imposed should not be altered, except in abnormal cases, until the period had expired, so that local authorities and traders would have some security as to the extent of their liabilities. He pointed out, however, that while the Royal Commission had suggested separate standards for domestic sewage and trade effluents, they did not appear to have discussed the possibility of intermediate standards for application to composite or abnormal sewages. Modified standards, based upon the 5 days' dissolved oxygen-absorbed test, could be devised for such cases without any real difficulty, although the task would be practically impossible with the permanganate test. In this connection, the author supported the recommendation of the Royal Commission for the creation of a central authority to deal with such matters. The remainder of the paper was mainly occupied with a discussion on the methods of sewage analysis, the author pointing out the greater number of analyses made under present conditions were of little value for purposes of comparison, serving only to guide those in charge of the particular works to which the analyses referred. The author expressed the view that the standardisation of analytical methods was long overdue and should be carried out without delay. It was also necessary, he said, to adopt a uniform method of recording results, and the paper concluded with a reference to the attempts already made to establish uniformity in this respect. It was also mentioned that a sub-committee of the Association of Managers of Sewage Disposal Works had been entrusted with the task of drafting standard methods of analysis for sewage and effluents, and that, in due course, the sub-committee proposed to make their recommendations the subject for discussion at a conference with representatives of other interested bodies.

Sludge Disposal.

At the afternoon meeting, which was presided over by Mr. I. G. Gibbon, two papers dealing with the question of sludge disposal were read and discussed. The first paper, by Mr. J. D. Watson, related to the digestion process of disposing of sewage sludge employed by the author at Birmingham. In this process, which makes use of the principles laid down by Clark, Travis and Imhoff, but employs shallow tanks instead of the two-storey tanks of Imhoff, the sludge from precipitation tanks is pumped into shallow tanks in which a process of fermentation, known as digestion, takes place, the digested sludge then being dried on drained beds formed of engine ashes. After removal from the drying beds, the sludge is further dried by a firm of contractors in large covered sheds, and finally ground, screened, and mixed with sulphate of ammonia, bone phosphates and sulphate of potash for use as a fertiliser. The digestion process, which is carried out in two stages, occupies some five months, so that a large tank capacity is required, those at Birmingham having a total capacity of 350,000 cubic yards. The drying beds consist of half-acre plots and have a total area of about 60 acres. The present-day cost of working the process, including interest on capital, amounts to 9·6*d.* per cubic yard of wet sludge with an average water content of 92 per cent. It has been found, in practice, that the whole area occupied by the digestion tanks is free from nuisance when working normally, and the sludge removed from the drying beds is entirely devoid of any objectionable odour. The sludge treated in this way, while retaining its nitrogen, is greatly reduced in bulk and weight, and almost entirely freed from grease which has been proved to be inimical to the fertilising properties of sludge.

The second paper, which was by Mr. John Haworth, described a series of experiments made at Sheffield on drying the sludge produced by the treatment of sewage by the bio-aeration or activated-sludge methods. Sludge directly discharged from the Dortmund tanks of an aeration plant was dried on specially prepared ash beds, the water content being reduced from 99·25 per cent. to 76·75 per cent. in 18 hours. After this treatment, the cake produced can be handled, and if left for a few days in dry weather, it dried hard, cracked and could be raked off. The treatment of a thin layer of sludge on a band of papermakers' gauze travelling slowly over a vacuum box was tried, as also were vacuum filters of the Oliver type. Satisfactory cakes were obtained by this process in some cases, while in others, with no apparent change in the conditions, the sludge formed no satisfactory cake, but clogged the filter cloth or gauze. Preliminary acid treatment of the sludge prior to vacuum filtration, as used in America, gave no improvement, and treatment in a centrifuge was also unsatisfactory. By prolonged settlement of the wet sludges, it was found that a separation of water to the extent of from 60 per cent. to 70 per cent. could be obtained in 24 hours, and by flotation processes with air or other gases, such as are used in the separation of mineral ores, rapid separation of a large quantity of water can be obtained. The production of gas by the addition of acid to a column of sludge containing a little chalk or carbonate of soda, thereby releasing minute bubbles of gas, was found to produce a separation of as much as 70 per cent. of the contained water from the sludge in one hour or less. In reviewing the experiments, the author remarked that most of the processes applied released the water contained in the interstices between the gelatinous particles composing the sludge, but did not appreciably affect that enclosed in the particles themselves, except possibly by capillary attraction or by evaporation. He thought that, for the time being, the drying of sludge on suitably prepared ash or sand filters appeared to be the most

practical and economical method for application on a large scale.

A long discussion, in which upwards of a dozen speakers took part, followed the reading of the two papers, but we are precluded by considerations of space from giving more than an outline of this. Several speakers referred to the difficulty of inducing farmers to purchase the dried sludge for manurial purposes, and to the freight rates charged for its transport which, it was suggested, augmented the difficulties of disposing of the sludge. Other speakers suggested that the presence of iron in the sewage of Birmingham and Sheffield facilitated the processes of digesting and drying the sludge. Mr. Weekes, in the course of his remarks, referred to the differences in the areas of sludge-drying beds in different plants, stating that these varied from 1 sq. yd. for five persons to 1 sq. yd. for 20 persons or more. Mr. Lamb said that, at Worcester, he had been obtaining satisfactory results by drying the sludge on sloping land. In calling on the authors to reply to the discussion, the chairman, who is assistant secretary of the Ministry of Health, said he was aware of the transport problem in relation to sludge disposal and the Ministry would endeavour to assist in any difficult cases reported. He asked whether the installation at Birmingham was capable of dealing with the whole of the sludge produced and also whether the process afforded a permanent solution of the problem.

Mr. Watson, who replied first, said the plant at Birmingham could deal with the whole of the sludge. With regard to the use of the dried sludge as a manure, he said the substance was very acceptable to farmers for the first year or two, but not afterwards, the difficulty being that it was applied in too large quantities. If a limited quantity only were employed, the results were quite satisfactory. The area of the drying beds at Birmingham, he said, was equal to 1 sq. yd. for three persons, and the speaker also referred to the use of the gas produced by the digestion process for power production. Full particulars of this application will be found on page 456 of our 112th volume. Mr. Haworth, who then replied, said he did not suggest that the drying of sludge on ash beds was the final solution of the problem, but that it was the most practical method at present available. The disposal of the dried sludge, he remarked, depended upon local circumstances. It was sent away to a tip at Sheffield and the cost, of course, depended largely upon what had to be done with it. To a speaker who had enquired as to the condition of the sludge when removed from the beds, Mr. Haworth replied that it was in a good spadeable condition and could be picked up and stripped off by hand; it would not consolidate again if piled in a heap. With regard to Mr. Lamb's experiments at Worcester, the speaker remarked that this was an even simpler method than his suggested process. With regard to the effect of iron, he could not see how this could possibly be beneficial to an aeration process or to the drying of the sludge. Actually he had been endeavouring for years to get rid of the iron, although if it were in any way advantageous it would be quite easy to add to it.

Water Supply Legislation.

The conferences of Friday, the 23rd instant, were arranged by the British Water Works Association, and the morning of that day was first occupied with the general meeting of the Association. The chair, at both the morning and afternoon meetings, was occupied by Alderman Charles H. Bird. After the business of the general meeting had been disposed of, Mr. A. R. Atkey, J.P., Chairman of the Water Committee of Nottingham, read a paper, the object of which was to focus public attention on the need for certain reforms in existing legislation relating to water supply. The author mentioned several anomalies and inconsistencies in this connection, but said that he proposed to deal exclusively with the matters of compensation water and underground water. The public, he said, had to pay far too dearly for the obsolete and illogical legislation relating to compensation water, conditions having changed since this legislation was enacted. Referring to the reasons for the failure of the water supply in the dry year of 1921, the author stated that one was that the demand for water had generally increased much faster than the supplies and the latter had actually diminished in some cases. Another reason was that very large volumes of compensation water were sent down streams for the benefit of derelict mills. Summing up his remarks under this heading, the author suggested that as the volume of compensation water had been calculated in the past upon uncertain data and was greatly in excess of the normal natural flow, involving great waste, the time had arrived for legislation to be formulated to meet the changed conditions and necessities of the day.

On the subject of underground water, the author stated that the present law practically permitted anyone to sink a well and abstract water without regard to the rights or requirements of his neighbours. A water authority, on the other hand, had to obtain Parliamentary sanction before they could sink a well for the public benefit, and might meet with considerable opposition and have to pay compensation to various claimants. Moreover, when the work had been carried out, a colliery shaft sunk close at hand might divert all the water without the colliery owners incurring any liability. The question of the pollution of underground water by sewage, &c., was another matter upon which further legislation was needed. Finally the author referred to the inventory of the water resources of the country now being prepared by the Ministry of Health, and called attention to the need for an organised system of collecting and collating data relating to water supply.

Compensation Water.

At the afternoon meeting, the first paper taken was one by Mr. F. W. Macaulay entitled "The Relation of Compensation Water to Stream Flow," in which the author said it was proposed to recommend to Parliamentary Committees that they should in future adopt actually measured stream flows as the basis upon which to assess the quantity of compensation water to be given to streams impounded for domestic supply purposes in place of the basis at present used, namely, the estimated rainfall upon the gathering ground. The rainfall basis, theauthor said, was originated some 70 years ago by Thomas Hawksley to meet the particular conditions then obtaining in certain industrial areas in Yorkshire and Lancashire. It was the extension of Hawksley's formula to all varying conditions which constituted the error that the author's proposal sought to remove. It was tentatively suggested that the normal dry-weather flow of a stream should be taken to be the mean over as many years as possible of the average flows during the lowest consecutive 14 days in each year, and that the flow thus obtained for each stream to be impounded should be taken as the basic figure for its compensation, the basic figure to be multiplied by such factor as the proved claims to water of mill owners and other riparian users might render necessary. The author gave some notes on the methods of obtaining the necessary stream flow records, and concluded by remarking that no original assessments of compensation water should be considered as final, but should be subject to revision by Parliament in the event of any party to them being able to prove that they were founded upon erroneous data.

Welsh Water.

The next paper, bearing the above title, was by Mr. G. R. Collinson, and it consisted largely of observations regarding the allocation of the water resources of Wales. The author stated at the outset, that while Wales made no selfish claim for the reservation of the whole of its magnificent catchment areas and reservoir sites for its own present and prospective use, it would certainly demand to be called fully into consultation with regard to the allocation of such surplus as remained after its own needs had been provided for. The first just claim upon the surplus seemed to rest with the neighbouring counties of Cheshire, Staffordshire, Shropshire, Warwickshire, Herefordshire, Worcestershire, and Gloucestershire, and although the Corporation of Liverpool drew upon the resources of Wales for its water supply, the author said that, in his opinion, the water requirements of the whole of Lancashire should most properly be met from the Lake District. The situation with regard to Liverpool had, however, to be accepted, but there was no room for adding further heavy demands from Lancashire, and neither should Liverpool or Birmingham be allowed to come south of the Dee and Severn, respectively, in developing future schemes of supply. As a rough approximation, he said that the total quantity of water available from Welsh sources was about 500 million gallons a day, this figure representing the full extent to which water schemes in Wales could be economically developed in addition to those already in existence. At the rate of growth of the population during the last century, this quantity of water would only suffice for the needs of Wales, the neighbouring counties, and Liverpool for about two centuries.

The only other communication taken at the afternoon meeting was a joint paper by Messrs. N. J. Peters, H. W. B. Cotterill and B. S. Crimp, who described, respectively, the Wenallt storage reservoir, the Llwynon impounding reservoir and a new pipe line now under construction for the waterworks undertaking of the Corporation of Cardiff. These papers, however, are mainly of a descriptive character and cannot be usefully summarised.

The conference of Saturday, November 24, arranged by the Institute of Cleansing Superintendents, discussed a paper by Mr. J. Jackson, dealing with transport work in the Salvage Department of the City of Birmingham, while that of Monday, November 26, had reference to the subject of small holdings and was arranged by the County Land Agents' Association.

Highway Bridges.

The conferences for the morning of Tuesday, November 27, were arranged by the Associations of Local authorities in conjunction with the County Surveyors' Society. The meeting was held under the chairmanship of Sir Henry P. Maybury, and the first paper dealt with was entitled the "General Construction of Bridges," the authors being Lieutenant-Colonel J. F. Hawkins and Captain C. G. Mitchell. The paper referred exclusively to highway bridges, and first dealt with the standard loading for such bridges as defined by the Roads Department of the Ministry of Transport. The standard loading, we may mention, is based upon a 20-ton traction engine drawing three 13-ton trailers, with 50 per cent. added for impact. The paper very briefly described the common types of bridges now employed for small, medium and long spans, giving notes on the special features of each type with respect to design, construction and maintenance. Reference was also made to the design of swing bridges and to the widening and strengthening of existing bridges, as well as to the use of high-alumina cements (*ciment fondu*) for reinforced-concrete structures. It was suggested, in view of the fact that recent tests have indicated a gradual increase in strength over a period of five years of concrete made with *ciment fondu* that a much higher working stress should be allowed on reinforced concrete structures when this material is employed. Particulars of the tests referred to will be found on page 631 *ante*. The paper emphasises the need for careful supervision in reinforced concrete constructional work, of the grading of the materials and of the measurement of water, and also compares the characteristics of steel and reinforced concrete bridges.

The paper gave rise to a lengthy discussion which turned largely upon the question of the allowance for impact on highway bridges. Most of the speakers expressed the view that the allowance of 50 per cent. was satisfactory for short-span bridges, but should be reduced in the case of bridges of long spans. Major H. M. Morgan, county surveyor of Essex, suggested that for bridges of from 80 ft. to 100 ft. span, the allowance should not exceed 25 per cent. This speaker also gave some interesting results of compression tests of 1 : 1½ : 3 concrete made with *ciment fondu*, mentioning that the average strength after 28 days was 8,160 lb. per square inch. He added that further tests would be made at intervals of six months over a period of several years. Lieutenant-Colonel Hawkins replied to various questions raised in the discussion, and Captain Mitchell, who dealt with the matter of impact allowance, remarked that for large and costly structures it was as well to have an extra factor of safety. The Ministry, however, were always open to reconsider the question for any particular case.

Road Reconstruction.

The second paper at the morning meeting was by Mr. W. P. Robinson, dealing with the reconstruction of the foundations of, and the carpets on, existing roads. In this paper, the author described some of the works in connection with the reconstruction, repair and maintenance of important main roads in the county of Surrey during the last three years. Many of the roads in Surrey are arterial roads radiating from London, and now carrying not less than 1,000 tons of traffic a day per yard width of carriage-way. It has been found necessary, during the last ten years, to convert the water-bound surface of these roads to a bituminous-bound or asphaltic surface. In connection with this work, the council installed two fixed plants for the production of asphalt carpets, a fixed plant for the production of sub-crusts or binder coats, and two portable drying and mixing plants for the production of bituminous sub-crusts. In carrying out this work, a reinforced concrete curb was first laid to provide lateral support for the new surfacing material, and, three or four weeks later, the road was scarified to a depth of 3 in. The scarified material was taken up, dried and mixed in the portable plant with a matrix of pitch and creosote oil, delivered on to the road, and rolled while hot to form a sub-crust for an asphalt carpet 1½ in. thick. The carpet was composed of 78 per cent. local sand, 10 per cent. of filler and 12 per cent. of fluxed Trinidad Lake bitumen, which was consolidated at a temperature of not less than 250 deg. F. The foundations consisted of previous coatings of flint and gravel macadam, varying from 8 in. to 12 in. in thickness, with a subsoil of chalk, sand or loamy gravel, and the width between curbs was not less than 20 ft. In connection with road foundations, the author suggested that, before resurfacing, the water-bound granite and part of the gravel should be scarified, taken up, and mined with hydraulic or bituminous cement, and relaid as a foundation or sub-crust. He also mentioned that he had abandoned the use of pitch, and is now using bitumen as a matrix for sub-crusts not exceeding 3 in. in. thickness; the bitumen is fluxed with petroleum

oil to a penetration of about 120 at 77 deg. F. In some cases, the author has strengthened the foundation by removing the existing water-bound macadam, washing and re-grading it, and using the material as the aggregate for a reinforced-concrete foundation upon which to lay a bituminous carpet. Reference is also made in the paper to the construction of a road with a cement-concrete surface. Good results, the author stated, were obtained by first dressing the surface with tar oil and then applying a dressing of hot or cold bitumen. For the surface dressing of macadam roads, the author recommends bitumen instead of distilled tar, remarking that this form of surface dressing is particularly suitable for new tar-macadam roads in order to fill any voids therein, as the bitumen is not so susceptible to changes of temperature and to displacement by traffic as tar is. He also referred to the use of an emulsion of bitumen which can be applied at normal atmospheric temperatures, stating that the results obtained appeared to justify its extended use. Specifications for tar macadam and asphalt carpets are given in the paper, and the author called attention to the advantages of refuse-destructor clinker as an aggregate, particularly for single-coat bituminous carpets.

Mr. Robinson's paper was also very fully discussed, and the first speaker, Mr. W. J. Hadfield, agreed with the author as to the advantages of bitumen in place of pitch for binding road materials, but said he preferred to use a heavy three-wheeled roller in place of the lighter tandem roller advocated by the author. Mr. W. J. Taylor asked if the author proposed to abandon two-coat work, which the speaker said was advantageous in that the additional bituminous sub-crust had the effect of strengthening the foundation. Mr. H. T. Chapman agreed with Mr. Taylor as to the advantages of two-coat work, but referred to the difficulty of stripping the worn carpet from the sub-crust when repairs were necessary. This point was also raised by other speakers, and, in his reply, the author said a method he had successfully employed was to burn off the carpet with a paraffin flame. This method, however, was slow and expensive, and there was room for the introduction of some form of machine for the purpose. To Mr. Hadfield's remarks as to the weights of rollers, the speaker replied that different rollers were required for different conditions. He agreed that heavy rollers were essential for consolidating foundations but preferred lighter rollers for surface carpets. With regard to two-coat *versus* one-coat work, the speaker said he did not advocate either in particular, adding that each class of work was useful under proper conditions.

Mechanical Appliances for Road Maintenance and Construction.

The afternoon conferences were arranged by the Institution of Municipal and County Engineers, two papers being submitted for discussion by Mr. E. Willis and Mr. Norman Scorgie, respectively. The chair was taken by Mr. W. T. Lancashire. The first of the papers, which dealt with estate roads and private street construction and standardisation, hardly comes within our province, and the subject-matter of the second, which was entitled "The Latest Types and Use of Mechanical Appliances in Connection with Road Maintenance and Construction," has been largely covered in our account of the machinery shown at the exhibition in connection with the Congress, and referred to above. We propose, therefore, to deal only with the discussion on this paper.

The first speaker, Mr. T. F. Franks, in the course of his remarks, referred to the utility of the thrust-borer for laying pipes, &c., under roads, and also pointed out that the author had made no mention of a very useful machine for washing old road materials for use as foundations of new roads or for the construction of concrete roads. Mr. Holden remarked that he had not been able to obtain results with compressed-air tools for road-breaking in any way equal to those given in the paper, and asked under what conditions those results had been obtained. He pointed out that the noise made by such tools was a serious objection to their use. Mr. A. E. Collins also expressed the view that the thrust-borer was a very valuable appliance, and added that he had obtained excellent results with the "Aero" concrete mixer, which had not been mentioned in the paper. Full particulars of this machine will be found on page 515 of our 113th volume.

In the course of his reply, the author, referring to Mr. Holden's remarks, said the results given in his paper in connection with the use of compressed-air tools had been obtained in the Metropolitan area, but pointed out that the figures would be greatly affected by the conditions of each particular case, and were therefore not comparable one with another. He was fully conscious of the fact that, owing to the short time at his disposal, reference to many excellent appliances had been omitted from his paper, but this had the advantage that the discussion was assisted by speakers calling attention to the omissions.

(To be continued.)

INDUSTRIAL NOTES.

The boilermakers having voted in favour of accepting the proposed agreement for ending the shipyard dispute referred to in our last issue, work was resumed last Monday in the various yards throughout the country. Re-starting, however, as may have been expected, can only take place by degrees. So far, the total figures of the ballot have not been divulged, and it is doubtful whether the next report of the United Society of Boilermakers and Iron and Steel Shipbuilders will give them, since the general secretary's remarks in the report for the present month do not refer to the dispute at all. But the quarterly report to September 29, now issued by the Associated Blacksmiths' and Ironworkers' Society, does so, and says that by reason of the dispute, which lasted some 30 weeks, not only boilermakers, but a large proportion of all shipyard workers have in consequence been on the streets, suffering. In most cases those other workmen have been refused their State Unemployment Benefit. According to the Associated Blacksmiths two things emerge from the dispute. The first is an alteration of the Unemployment Insurance Act under which workmen who have subscribed for such benefit and are not directly involved in the dispute should receive it. The second is found, if anything, more imperative still, and is the introduction of machinery between the several unions themselves, and between the unions and the employers, which will make impossible the repetition of the suicidal policy "we have recently pursued." The report adds that given the proper spirit on both sides such machinery is possible, and, judged by the results of the disputes in the Federated Shipyards during the last few years, it is imperative. From this statement, the Associated Blacksmiths would not seem to be very partial to the action which was taken by the boilermakers. The secretary of the London Iron and Steel Exchange, in reporting upon the meeting of that body held last Tuesday, says that the demand for iron and steel on the part of home consumers has steadily broadened of late; "it is difficult to over-estimate," he adds, "the beneficial effect of the settlement of the boilermakers' dispute upon all branches of the industry."

The report of the Blacksmiths' Society to which we refer above states that the membership at the close of the quarter to September 29 was 12,949. The total income for the quarter amounted, in round figures, to 29,204*l.*; this included 20,764*l.* received from the Ministry of Labour and 1,850*l.* from the Board of Health. The contributions were 3,969*l.*, a reduction of 293*l.* when compared with the preceding quarter. Expenditure was returned at 28,813*l.*, including 20,892*l.* for State Unemployment and Administration Expenses. That for State Health Insurance and Administration was 1,866*l.*

In the course of the proceedings before the National Wages Board (Railway Act, 1921), Mr. Bromley gave publicity to a question put by Major Hunt to the South African Minister of Railways and Harbours, asking for the maximum rates, excluding overtime and allowances, of certain grades, and the figures given for 1923 were:—Drivers, 19*s.* 9*d.* per day; firemen, 13*s.* 10*d.* per day, when passed, and 13*s.* as ordinary firemen before passing for a 48-hour week. Mr. Bromley had in his possession the rates of drivers, firemen and cleaners of New South Wales, for an 8-hour day, and quoted: Cleaners under 17 years of age, 6*s.* 6*d.* per day; of 17 to 18 years of age, 7*s.* 4*d.* per day—that was, added Mr. Bromley, more than a cleaner received in this country at 29 or 39, if he lived long enough; from 18 to 19 years of age the wage was 8*s.* 6*d.*; from 19 to 20 years of age it was 9*s.* 6*d.*—equal, Mr. Bromley said, to the wage of a "British" fireman; adults from 20 to 21 years of age had 10*s.* 9*d.* per day—more than the third and fourth year of a "British" fireman; and adults over 21, 13*s.* 6*d.* per day—or 6*d.* more than the first two or four years of a "British" engineman. The New South Wales fireman for the first twelve months received 14*s.* per day—equal to the fifth year's wage of a "British" engineman. For the next eighteen months he received 15*s.* per day—equal to the maximum of a "British" engine man. Thereafter, he received 1*s.*, making the wage up to 16*s.* per day—which was 1*s.* above the maximum rate of a "British" locomotive driver. Drivers in the first year received 17*s.* per day—which was 2*s.* per day above our maximum; in the second year they received 18*s.* per day; in the third year, 19*s.*; in the fourth 20*s.* per day—which was, Mr. Bromley stated, what was being asked for here after the fifth year, but was now 5*s.* above the maximum here. And, he added, the New South Wales railways classify, because on train runs of over 65 miles a day the drivers received 21*s.* Mr. Bromley, in reply to a question, said he had asked about the cost of living as against the above wages, and found reported only a very little difference, except with regard to clothing, which was cheaper here. This is interesting, seeing that a high tariff is in force in the Dominions.

The Swedish engineering industry, says *Swedish Export*, has been particularly exposed to dumping from Germany owing to the low rate of exchange. In this respect, however, a certain relief has now been experienced inasmuch as the competition from the Ruhr ceased with the occupation of that district. Nevertheless, the Swedish market is disturbed by low German offers at prices which do not cover the cost of production of the Swedish article.

The need of education has brought about another armistice between organised labour and employers says *Iron and Steel of Canada*. From Pittsburgh comes the report that 65 sheet metal union apprentices have begun a four-year training course at the Carnegie Institute of Technology, and will be paid their regular wage by their employers for the time spent in school. This is the result of a novel agreement made between the Pittsburgh Local Union No. 12, the Amalgamated Sheet Metal Workers' International Alliance, and the Sheet Metal Contractors' Association, Pittsburgh. While purely a local measure in its scope, the contract is regarded by educators, employers and union officials as the forerunner of similar agreements to be made, leading towards the proper training of union trade apprentices.

The question of apprenticeship is also one which forms the subject of papers being read and discussed at the present time at meetings in Paris of the Société des Ingénieurs Civils de France. The papers deal with the practical and theoretical training of apprentices, and go deeply into the subject under its various aspects. The discussion is to be closed at the meeting of the Société on December 7, when a number of resolutions are to be passed. We hope to return to the matter in a later issue.

A note in *The Iron Age*, New York, is to the effect that the fundamental cause for the hard times among the farmers is that theoretically they are members of the capitalistic class; they are owners of property which they expect to bear fruit. There is, therefore, economically, no common ground between them and the body of wage earners. Mr. Gompers, our contemporary, adds, misses this when he advises the farmers to "unionise" as a means of curing their troubles. He might as well advise the stockholders in industrial companies to "unionise" themselves, some of them having troubles as acute as those of the farmers. The distress of the farmers looms large for the reason that they are numerically the largest branch of the capitalistic class, though, our contemporary further states, they cannot be called the most intelligent. It is somewhat difficult to follow the argument. It would seem that the direct fundamental cause of the farmers' trouble is that their property does not bear sufficient fruit. Possibly this is owing to the fact that men will not work for them because they are capitalists. If such is the case, the lack of intelligence would be on the men's side. In every country of the world farmers have always been quite capable of conducting their business (weather permitting), but not always at a profit similar to that derived from other industries.

The Electrodeposition of Manganese.—When Bunsen first electrolysed aqueous solutions of manganous chloride in 1854, he obtained metallic sheets which oxidised almost as quickly as potassium. Subsequent experimenters had the same difficulty and were also much troubled by the formation of oxidic compounds in the bath, leading to the deposition of metals impure with oxide. As a consequence electroplaters have almost given up the hope of obtaining good manganese deposits; whether or not those deposits would prove hard and strong and technically useful is still unknown. Most of the studies of the "Electrodeposition of Manganese," which Drs. A. J. Allmand and A. N. Campbell, of King's College, London, described before the Faraday Society, on November 12, were also unsatisfactory. They first tried the simple manganous sulphate or chloride at high salt concentration and current density, varying temperature, acidity and also current density; they separated anolyte and catholyte by a diaphragm and kept both solutions in continuous circulation; but the deposits were mostly impure, or if pure, loose or inclined to flake. The chloride gave on the whole better results than the sulphate. Various additions to the electrolyte did not improve matters much. Finally they also tried, again with partial success only, the mixture of manganous chloride with ammonium chloride and hydrochloric acid, with which Grube and Metzger quite recently obtained good manganese deposits for their electrochemical study of manganese. Grube did not give particulars of his process, nor did he state the nature of his anodes; Mr. Campbell always used platinum, but he could not prepare large amounts of manganese in coherent form. Evolution of hydrogen during the electrolysis was found to be unfavourable to good deposits; but the brittleness of the manganese deposited did not appear to be due to hydrogen, since heating to 800 deg. C. in a vacuum did not remove the brittleness.

ELECTRICITY SUPPLY IN THE WEST RIDING.

The scheme for a Joint Electricity Authority which is being put forward by the Electricity Commissioners for the West Riding of Yorkshire is of considerable interest and involves some points of novelty, which may possibly ultimately be found to be worthy of attention in connection with the very complicated situation in London. The West Riding District includes such important towns as Barnsley, Bradford, Dewsbury, Halifax, Huddersfield, Leeds and Wakefield, all of which have municipal electrical supplies in operation, and have their own generating stations. There are also various other municipal stations at Keighley, Ilkley, Shipley, &c. The Yorkshire Electric Power Company and an associated company, the Electrical Distribution of Yorkshire, Limited, have at present power to supply over a large part of the area covered by the district, and the methods which are proposed to reconcile the interests of the various authorities concerned are of more than local interest.

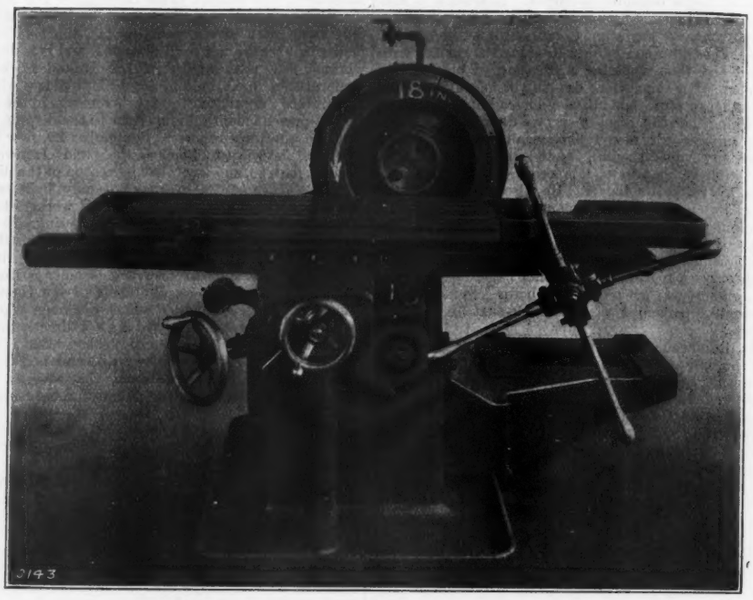
It is proposed to schedule part of the Electricity District as a reserved area which is to be administered by the Joint Electricity Authority. This area, which includes Bradford, Halifax, Huddersfield, Leeds, Keighley, Morley, Pudsey, &c., covers part of the present authorised district of the Yorkshire Electric Power Company, and it is proposed that this company shall surrender its rights in this reserved area in exchange for power to supply in parts of the Electricity District lying outside the reserved area, but not at the present time within its sphere. In addition the company is to supply electricity in bulk to the Joint Authority for use within the reserved area to the extent of 20,000 k.v.a. This supply is to be taken in successive amounts of 5,000 k.v.a. after due notice to the company. This scheme apparently has the advantage of allowing the Yorkshire Electric Power Company to retain the advantages of private ownership and management, and gives a fair chance of a practically municipal Joint Authority coming into existence. The Joint Authority is to consist of 28 members, of which by far the majority will represent local authorities, the only outsiders being two representatives of the Power Company, one representative of other company undertakers and two representatives of railway companies.

For the generation of electricity within the district the standard of three-phase, 50 periods, is to be used, with 33,000 volts for main transmissions and 11,000 volts and 6,600 volts for secondary transmissions. In the reserved area it is proposed to utilise municipal stations at Halifax, Keighley, Huddersfield, Bradford and Leeds, while further municipal stations at Ilkley, Huddersfield and Shipley, and the traction station at Leeds are to be shut down as soon as alternative supplies become available. Various interconnecting transmission lines are to be laid. Outside the reserved area the municipal stations at Barnsley and Wakefield, and the Power Company's station at Ferrybridge, are to be utilised. Municipal stations at Batley, Dewsbury, Hebden Bridge, Heckmondwike, Holmfirth and Tadcaster and the stations at Belle Isle and Castleford belonging to the Yorkshire Electric Tramways Company, are to be closed down as soon as alternative supplies become available. The Barugh and Thornhill Stations of the Yorkshire Electric Power Company are also to be utilised under the scheme, but are not to be further extended. These proposals are the outcome of an inquiry held in the district, but a further local inquiry is necessary before they can go forward for confirmation by the Ministry of Transport. The date of this second local inquiry has not yet been determined.

Thermal Conductivities of Metals, Solid and Liquid.—The recent experiments of W. Byron Brown, of the Ohio State University, on the thermal conductivities of some metals, were made with cylindrical specimens, 1·5 cm. diameter, 12 cm. high, each cylinder being surrounded by a slate tube, over which a brass tube was fitted. The upper portion of the cylinder was heated by means of a coil of nichrome wire; the lower portion was cooled by means of flowing water. The metals tried were tin, lead, cadmium, thallium, and some of their alloys. In all the cases the conductivity of the solid decreased considerably with rising temperature, but at very different rates; in the liquid metals and alloys the conductivity increased slightly with rising temperature. We give a few figures, stating melting-point m.p., and other temperatures in degrees Centigrade, and conductivities K in absolute measure: Tin, m.p., 232 deg. C.; K 0·1428 and 0·0767 at 50 deg. and 347 deg.; cadmium, m.p. 320 deg., K 0·200 and 0·105 at 45 deg. and 380 deg.; lead-antimony (ratio 87 : 13), m.p. 248 deg., K 0·063 and 0·0455 at 34 deg. and 372 deg.; lead-bismuth (46 : 54), m.p. 130 deg.; K 0·0236 and 0·2588 at 42 deg. and 285 deg. For thallium (m.p. 302 deg.), Cohen assumes three different modifications of the metal with transition points at 65 deg. and 95 deg.; the conductivity curves gave some indications of these changes. At the melting-point the conductivity of tin decreased by more than one-third, that of cadmium by one-half, that of tin-zinc (92 : 8) by two-thirds.

18-IN. SURFACE GRINDING MACHINE.

CONSTRUCTED BY THE GRAHAM MANUFACTURING COMPANY (INC.), PROVIDENCE, R.I., U.S.A.



In the accompanying figure we illustrate an horizontal spindle surface grinding machine constructed by the Graham Manufacturing Company, 71, Willard-avenue, Providence, R.I., U.S.A. The machine is of the knee type and it is made to take an 18-in. wheel. The knee is supported by a telescopic screw protected by a casing. The table is of the milling machine pattern and moves on wide slides, the end movement being 24 in. and the cross traverse, towards or away from the wheel, 3½ in. The table itself measures 13 in. by 44 in. and a pan 15 in. long extends at one end. The table top can be traversed to within 1¼ in. of the spindle centre, or lowered to 10 in. below it. The size of work taken is up to 18 in. long by 9 in. high. A recent improvement is the special design of pilot wheel by which the table and work are traversed across the face of the wheel. The handles of this are collapsible, being hinged in the boss so that they may be swung forward to clear any projection of the work beyond the table. This, while keeping the spindle of the pilot wheel short, and making the whole more compact, at the same time makes it possible to accommodate on the table long and awkward pieces which could not be traversed for the full length if the handles were fixed. The machine is built for accurate work, and the cross slide has micrometer graduations.

The spindle runs in Timken roller bearings, and, in order to limit end play, the rear bearing is held in a race which is kept constantly pressed in an outward direction by a powerful helical spring. The normal spindle speed is 800 to 850 r.p.m. The machine can be driven by belt or motor. The one illustrated is provided with a heavy bracket to carry a motor, which, for an ordinary range of work, should be between 15 and 20 h.p., though for special work 10 h.p. may be found to suffice. The chuck is of pressed steel, and the abrasive ring wheel is held in place by two wedge segments which are drawn in towards the back, inside the rim.

A Brown and Sharpe centrifugal pump supplies water to the wheel, the column being used as a large water tank.

ROYAL METEOROLOGICAL SOCIETY.

The usual monthly meeting of this Society was held on Wednesday, November 21, at 49, Cromwell-road, South Kensington, Dr. C. Chree, F.R.S., President, in the chair, when the following papers were read:—

1. "*Attempts to Measure Air Temperature by Shooting Spheres Upward.*" By Lewis F. Richardson, B.A., F.Inst.P. Whilst making observations of the upper wind in the manner described elsewhere (Phil. Trans. R. Soc. 223 (ser. A), 1923, pp. 345–382; also Meteorological Office, Professional Notes, No. 34, M.O. 245n.) by shooting polished steel spheres upwards in a direction slightly inclined from the vertical so that the wind caused the returning sphere to fall quite close to the gun, the writer enquired whether the time of absence of the sphere afforded a measure of a mean temperature of the air through which it had passed. After correcting for various disturbances the final result was that the upper air temperature was measured from the means of six shots with a standard error of 1 deg. C. at sunrise in calms or light winds. It is just on such occasions that there is often a layer of cold stagnant air near the ground, so that the temperature in the Stevenson screen is a poor guide to the temperature at 70 metres. Here the projectile may be useful.

2. Colonel H. G. Lyons, F.R.S., exhibited a replica of an early Korean Raingauge (circa 1770). Mr. F. J. W. Whipple exhibited a limit-gauge for rainfall. Insurance against rainfall is frequently dependent on whether the amount measured exceeds 0·10-in. The glass vessel exhibited has been designed to show with precision whether such a limit has been passed.

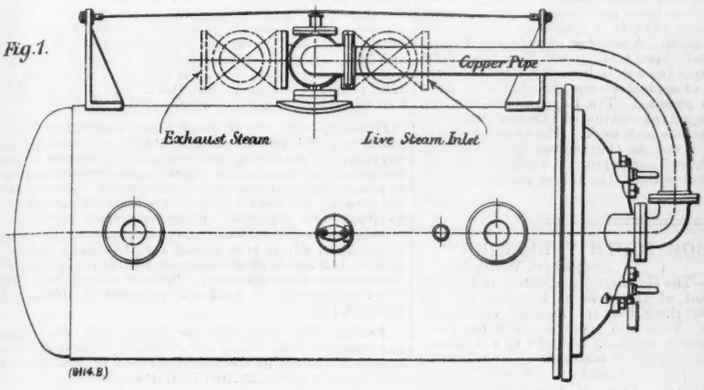
3. "*On the Distribution of Air Density over the Globe.*" By S. N. Sen, M.Sc., A.Inst.P. The paper begins with a discussion of the distribution of air density over the globe and the annual range of this element at mean sea level. Assuming certain lapse rates of temperature with height in summer, the air density aloft is computed, and charts are drawn showing the distribution over the globe in each layer from 1 to 10 km. above mean sea level. Thirteen charts of "isopycnics" or lines of equal air density are drawn depicting the density distribution at the various levels. The constancy of the air density at the 8 km. level all over the globe is illustrated in the chart for that level. It is also shown that the air density is controlled by temperature up to a height of about 8 km. and by pressure above that level. The name "thermosphere" is proposed by the author to denote the atmosphere shell in which temperature is the controlling factor and "barosphere" in which pressure is the controlling factor. The author then discusses the effect of increasing or decreasing insolation on density changes. It is shown that on the average when the temperature is rising in one hemisphere there is a diminution of air density in the thermosphere and an increase in the barosphere and the effect of diminishing temperature in the other hemisphere is the reverse. The author suggests that as a result of the opposite thermometric tendencies in the two hemispheres a mechanism is brought into being for the automatic breaking down of the stratification of the free atmosphere. This mechanism or the "convective cycle" which is postulated to be established between the North and the South poles also affords a means for the interchange of air between the two hemispheres.

Swedish Fishermen on the Argentine Coast.—We read in *Swedish Export* that an expedition of some interest is that of a party of West Coast Swedish fishermen to Argentina, where they are going to attempt introducing their own fishing methods. The combined motor and sailing smacks of these fishermen have been modernised and improved of recent years, which has increased the capacity of the fleet far beyond the requirements of the Swedish market. A great many boats are even now engaged on the British coast and as far as Newfoundland. A motor smack of the Scandia make has now been fitted out for fishing on the banks outside Mar del Plata. It is of the Swedish "koster" type of 5 tons capacity, equipped with refrigerator, and having a crew of eight men. As fishing is now carried on only in small boats which cannot fish in bad weather, and are unable, besides, to go up to Buenos Ayres with their catch, it is expected that the present venture will prove profitable.

STORAGE CALORIFIER FOR HOT WATER SUPPLY.

CONSTRUCTED BY MESSRS. ROYLES, LIMITED, ENGINEERS, MANCHESTER.

Fig. 1.



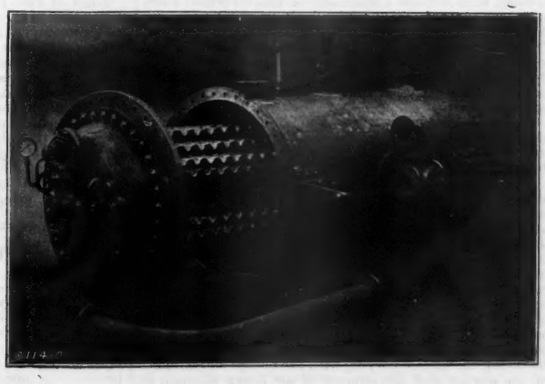


FIG. 2.

Fig. 3.

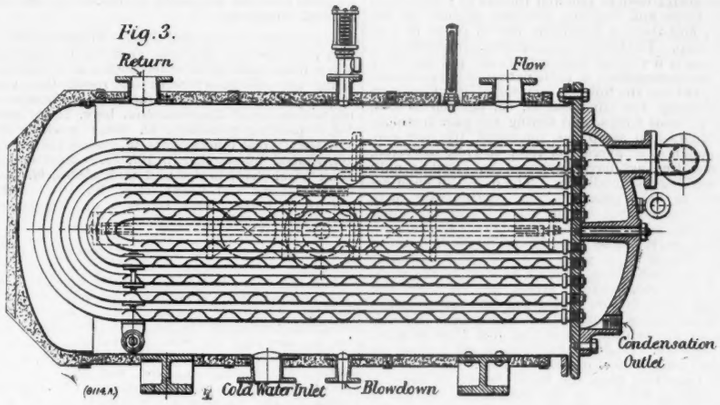
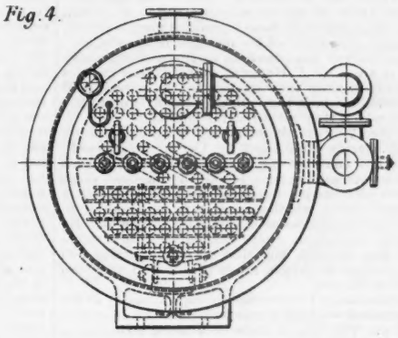


Fig. 4.



WE illustrate above a storage calorifier constructed by Messrs. Royles, Limited, Irlam, near Manchester, and specially suitable for supplying hot water, either salt or fresh, for baths, lavatories, &c., on ships or in large institutions on land. The particular example illustrated is of heavy design, and is constructed almost entirely of copper to avoid trouble due to corrosion. It is capable of heating 5,000 gallons per hour from 50 deg. to 150 deg. F., using exhaust steam at 12 lb. per square inch pressure. The photograph reproduced in Fig. 2, shows the calorifier with the tubes, partially removed for inspection or cleaning, and its design and construction can be followed by examining the plan, longitudinal section and end elevation given in Figs. 1, 3 and 4, respectively. The storage cylinder, shown in section, in Fig. 3, is formed of copper plates, with one end dished and the other closed by a flat mild steel tube plate having an internal lining of copper. The tube plate is secured to the flange of the copper cylinder by means of bolts passing through a steel strengthening ring at the back of the flange, as shown in Fig. 3.

The cylinder is supported on two cast-iron blocks, best shown in Fig. 4, and the fittings include a flanged cold-water inlet and blow-down connection at the bottom, flanged connections for the flow and return pipes of the circulating system at the top, a relief valve and thermometer, all of which are shown in Fig. 3. The cylinder is well lagged with magnesia and asbestos covered with planished steel sheets, which are supported on wooden rings and held in place by brass bands.

The heating elements consist of solid-drawn copper tubes indented under the well-known Row patent and bent into "U" shape. There are 35 of these tubes, which, in the aggregate, give a heating surface equivalent to 381 sq. ft. of plain cylindrical tubing. The method of fixing the ends of the tubes into the tube plate will be clear from an inspection of Fig. 3, which also shows the dished cast-iron cover used to convey the steam to the tubes and to collect the water of condensation. The cover is secured to the tube plate by studs through the flange and by a row of six long studs passing through the horizontal rib which divides the cover into two compartments covering the inlet and outlet ends of the tubes, respectively. Steam is supplied to the inlet compartment, which is fitted with a pressure gauge, through a 4-in. copper pipe from a control valve, mounted on the side of the cylinder as shown in Figs. 1, 2 and 4. The control valve has two inlet connections, one for the exhaust steam normally employed and the other for live steam which can be used when no exhaust steam is available.

The opening of the valve, and consequently the supply of steam to the tubes, is automatically controlled in accordance with the temperature of the water by means of the device shown in Figs. 1 and 2. Reference to the latter will show that a long steel strip, stretched between two brackets mounted on the side of the main storage cylinder near the ends, is arranged so that one side of the strip is in contact with the stem of the control valve. The strip is slightly bent, as shown in Fig. 1, so that, as the cylinder expands, owing to a rise in temperature of the water, the increased tension on the strip tends to straighten it and thus partially closes the control valve and reduces the supply of steam to the tubes. If the temperature of the water in the cylinder falls, owing to a large quantity being drawn off, the reverse action takes place and the control valve is opened by a spring on the valve stem. By this means the temperature of the water is kept practically constant irrespective of the demand.

The tubes are easily removable for cleaning, which is of course particularly necessary when sea water is being used. This can be done, as shown in Fig. 2, by removing the bolts from the tube plate and disconnecting the steam pipe; the steam joint between the dished cover and the tube plate, however, need not be broken. Two eyebolts are fitted into the cover to facilitate the withdrawal of the tubes. In connection with this operation it should also be pointed out that the inner ends of the tubes are clamped between steel plates and supported on two rollers which rest on the bottom of the cylinder. These rollers, of course, serve to support and guide the tubes while they are being withdrawn.

We understand that a large number of calorifiers similar to that illustrated have been supplied for use on large passenger steamers of several well-known lines, for which application they have the important advantage of occupying much less space than the older arrangement employing large galvanised iron tanks heated by coils of ordinary tubing. They have also been successfully employed for the hot-water services of hotels, hospitals and other institutions, as well as for heating buildings.

THE BIO-AERATION OF SEWAGE.*

By ARTHUR JOHN MARTIN, M.Inst.C.E.

TEN years ago the design of sewage-purification works appeared to be more or less standardised. A strong Royal Commission had carried out an exhaustive investigation, extending over many years; and their recommendations were generally adopted as a basis for the design of works of sewage disposal. While the Commission was still sitting a new process of sewage purification had made its appearance, which bids fair to supersede some of the methods now in use. Attempts had already been made to purify sewage by blowing air through it. The subject was studied by Dr. Angus Smith in 1882, since when many experiments in this direction had been made, none of which had resulted in a practical process. In 1912, however, as the result of observations of the effect of certain green growths on the aeration of polluted waters, experiments were put in hand at the Lawrence Experiment Station in which sewage was aerated in a tank filled with vertical slabs of slate. Following these experiments, and some which he himself had carried on with an organism known as "M 7," Professor G. J. Fowler suggested to Messrs. E. Ardern and W. T. Lockett that new work should be carried on on similar lines. The method adopted was to draw air continuously through successive samples of sewage in large glass bottles in which the deposited solids were allowed to accumulate. As the quantity of deposited matter increased, the time required for the oxidation of the sewage gradually diminished; and the conclusion was reached that the solids (or "activated sludge") obtained by prolonged aeration have the property of enormously increasing the purification of the sewage by aeration, and that the results thus obtained are at least equal to those yielded by efficient bacterial filters. This observation was confirmed in a series of experiments on a larger scale. The sludge must be kept circulating continuously at a velocity variously estimated at from 1 ft. to 2 ft. per second. The volume of air required is from ½ cub. ft. per gallon upwards, according to the strength of the sewage.

At Sheffield and Bury, owing to trouble experienced

* Abstract of a paper to be read before the Institution of Civil Engineers on Tuesday, December 4.

from the choking of diffusers, mechanical means have been adopted for keeping the sludge in circulation. At Sheffield an experimental tank is divided by longitudinal walls into channels 4 ft. wide and 3,544 ft. in total length, along which the sewage circulates continuously, being propelled by 18 paddle wheels. At Bury the tank is circular, with a coned bottom and an inner vertical tube, up which the sewage is drawn by a rotating cone and thence flung in a thin film across the surface of the tank. The power required for mechanical agitation is 15 h.p. to 50 h.p. per 1,000,000 gallons per diem, depending on the strength of the sewage. The results obtained are comparable with those from air-blowing. The process is very sensitive to changes in the nature of the sewage.

The sludge produced is very voluminous. It is rich in nitrogen and phosphates, but contains 97·5 per cent. to 99·5 per cent. of water; and so far the problem of drying it remains unsolved.

The process is being widely adopted both in this country and in America; but the principles underlying it are as yet imperfectly understood. Much scientific work has already been devoted to their elucidation; and more is urgently required. Several observers have suggested that the agencies concerned in the process are mainly physical, and that the sludge performs a merely mechanical function. The balance of scientific opinion is opposed to this view. Up to a certain point, however, the action of the sludge is undoubtedly physical, for it sweeps the colloidal matter out of the sewage. When the sludge is examined under a microscope it is seen to be wholly bacterial, the species varying with the nature and strength of the sewage and the amount of air blown through it. Larger organisms are also present. The small red worms which are found in large numbers in certain sludges were thought at one time to play an important part in the purification of the sewage, but their presence has been found to be merely incidental.

Well-aerated sludges contain enormous numbers of protozoa, which feed on bacteria; and it has been proposed to kill them off by the selective action of certain dyes. The cell-content of these organisms may, however, furnish a large proportion of the nitrogen in the sludge.

Much controversy has arisen as to the aerating value of bubbles of air. Mr. J. Haworth contends that bubbles do not readily give up their oxygen to the sewage, and that the aeration which they effect is chiefly due to the disturbance which they set up at the surface.

The accepted views of the rationale of the bio-aeration process are sharply challenged by Dr. A. M. Buswell, who points out that the organisms of which activated sludge are composed are also found in stagnant pools and ditches. He carried out some experiments with a view to ascertaining whether oxygen is as essential to the success of the process as is generally supposed. He reached the conclusion that stirring is much more important than oxygen, and that activated sludge will grow and develop at oxygen levels so low that they can scarcely be measured.

There is a tendency to economise in capital outlay at the cost of increased working expenses; but this is a mistaken policy. The largest item in working expenses is usually the cost of power, which may be economised: (*a*) by limiting the work to be done; and (*b*) by employing the power to the best advantage. The aeration of sewage brings about a great improvement in a very short time; but the results from a prolongation of the treatment are usually meagre. The amount of purification effected in 5 hours following the first hour's treatment is often no greater than is accomplished by an ordinary filter in one, while the quantity of sewage which can be dealt with by a filter is more than doubled by an hour's bio-aeration treatment. In many cases it will be most economical to complete the purification by filtration. A further economy of power may be effected by admitting to the aeration tank no more sludge than is absolutely necessary.

There are many ways of using power to agitate sewage. Screw propellers should be efficient, but have not been widely used. Centrifugal pumps afford a useful means of drawing in air and mixing it with the sewage. They have been tried with good results in America. The efficiency of the type of paddle wheel which is generally used is low; but it is doubtless adopted for the sake of the splashing which it effects.

The conclusions which have been drawn as to the relative efficiency of different modes of agitation are usually misleading, being based on figures which are not comparable. The diffused air method is heavily handicapped by the loss of power in compression; but it compares more favourably with mechanical agitation than might be expected. The low efficiency of the latter method is due to the power expended in splashing and that lost by friction against fixed surfaces. Splashing appears to be necessary in certain cases; but the need might possibly be reduced by skimming off the oil, &c., which covers the surface of the sewage. The power expended in overcoming surface friction is absolutely wasted, and may be greatly reduced by attention to the design of the tank. It is doubtful whether the best form of tank has yet been evolved.

Local authorities often desire to adapt their existing works to the new process; but the saving thus effected will usually lead to increased working expenses. Where, however, a long outfall sewer is available, there may be advantages in using it as a bio-aeration tank, the velocity of the normal flow in it being usually ample for the purpose.

It would appear that the requirements of the bio-aeration process as regards chemical supervision and continuous agitation are less exacting than was originally supposed. In designing works on this principle to deal with a particular sewage, it is necessary to know: (1) the least amount of air which will suffice to purify it; (2) the most effective mode of introducing the air into the sewage; (3) the volume of sludge which will give the best results; (4) the lowest velocity of circulation which will prevent the deposition of the sludge; (5) whether the sewage will be best dealt with fresh, or after a preliminary septic action; and (6) given these fundamental data, the form of tank in which the desired conditions can be provided with the greatest certainty and at the lowest cost.

There is also the important question of the disposal of the sludge. Before these questions can be answered with certainty, there must be a firm basis of scientific fact on which to build. A number of valuable investigations have already been made; but they have done little more than point the way to lines of further research. In no department of applied science probably is the need for research more pressing. The Royal Commission on Sewage Disposal urged the creation of a Central Authority competent to undertake such work. The question of cost stands in the way; but the country cannot afford to go on spending 7,000,000*l.* per annum on works of sewerage and sewage disposal without the fullest guidance which science can give.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—The threatened dislocation of business due to the advent of the General Election has not materialised in anything like the measure anticipated in some quarters. Here and there inquiries are being held up, but generally speaking the tone of the market both as regards semi-finished materials and engineering products is more optimistic than at any period during the past twelve months. Prices all round are beginning to respond to the slightly improved demand. Steel billets are dearer despite renewed threats of Continental dumping, forge and foundry iron are slightly in the ascendant, and there is a uniform rise in prices of iron and steel scrap. The latter is an important consideration, indicating as it does that steel-makers are putting more furnaces into commission, in anticipation of the increased requirements from the finished sections. Heavy melting basic steel scrap has advanced 7*s.* 6*d.* per ton to 95*s.*, delivered at local works, and during the past fortnight heavy wrought-iron scrap has advanced 10*s.* per ton, and now stands at an average of 105*s.* to 110*s.* delivered. Borings and turnings have advanced 5*s.* Rolling mills are still working spasmodically. The orders in hand are insufficient to keep plant running continuously, with the result that current output has to bear an unfair burden in the shape of overhead charges. The outlook has slightly improved as regards the forges and heavy foundries. There is a good deal of work awaiting execution on shipbuilding account as soon as the worst effects of the boilermakers' strike can be overcome. Basic steel manufacture comprises the most active feature of the heavy steel trades. Furnaces in Sheffield and district are working something like three-quarters of their capacity. Lincolnshire furnaces are turning out over 12,000 tons of steel ingots per week. The bar iron mills are benefiting from the larger orders on hand at wagon building works. In the engineering section an order has been received locally for a large machine to weigh approximately 50 tons for grinding chilled rolls for use in the rolling of steel sheets. It is stated that this machine will be one of the largest ever made for the purpose. In the lighter trades the manufacture of joiners' tools and excavating tools has received an impetus from increased sales both on home and Colonial account.

South Yorkshire Coal Trade.—The market shows little change. Maximum quotations in the main are firmly adhered to, the colliery position being strong despite the continued shortage of wagons. The home demand for best steam hards is on a rising scale, while the outputs for shipment *via* Hull continue to absorb a very large tonnage. Cobbles and nuts are not quite so firm owing to open market disposal of surpluses. Lancashire is taking slightly increased deliveries of slacks. Bunkering fuel is a moderate market. There is a rising demand on export account for gas cokes. Quotations:—Best branch handpicked, 31*s.* 6*d.* to 32*s.* 6*d.*; Barnsley best Silkstone, 27*s.* 6*d.* to 29*s.*; Derbyshire best brights, 27*s.* to 29*s.*; Derbyshire best house coal, 23*s.* to 24*s.*; Derbyshire best large nuts, 21*s.* to 22*s.*; Derbyshire best small nuts, 15*s.* to 16*s.*; Yorkshire hards, 21*s.* to 23*s.*; Derbyshire hards, 20*s.* to 22*s.*; rough slacks, 12*s.* 6*d.* to 13*s.* 6*d.*; nutty slacks, 10*s.* to 12*s.*; smalls, 5*s.* to 8*s.*

South African Coal.—We read in *The South African Mining and Engineering Journal*, that official tests of coal from the mines of the Société Minière et Géologique du Zambéze, at Tete, have recently been made at the sisal factory and in the locomotives of the Mozambique Industrial and Commercial Company, at Chupanga, from the first tonnages brought down this year. The tests proved that the evaporative power of Zambesi coal is equal to 82 per cent. of the best Yorkshire coal, and that it contains from 13 per cent. to 14 per cent. of ash and 24 per cent. of volatile matter.

Potash Recovery at Swedish Cement Works.—According to *Swedish Export*, the Swedish Board of Trade has recommended that the Slite Cement Works on the island of Gotland be granted a government loan for extending its plant for production of potash on the Jungner method. The Board says that in view of the large Swedish importation of German Stassfurter salts for fertiliser purposes, amounting to 10,000,000 kronor, it is of importance to ascertain how far the Swedish raw material can be utilised to compensate for this import. The conditions at Slite for recovery of potash from the clay according to the Jungner method seem to be very favourable, and the Board therefore thinks it probable that the results will prove encouraging.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Home demand for Cleveland pig-iron continues to expand rather rapidly and values are very strong. Export business is very quiet, but there are one or two inquiries from abroad, and hope is entertained of some early improvement in foreign trade. Stocks at makers' yards are understood to be very low, and little extra pressure for delivery is needed to create rather acute shortage. No. 1 is 107*s.* 6*d.*; No. 3 g.m.b., 100*s.*; No. 4 foundry, 98*s.* 6*d.*; and No. 4 forge, 97*s.* 6*d.*—all f.o.t. makers' works, and f.o.b. Tees.

Hematite.—Output of East Coast hematite is well taken up, and prices continue slowly but steadily to advance. A gratifying and encouraging feature is the inclination of customers to negotiate for forward supplies at rather higher figures than current rates. Local needs are growing and further sales to the Sheffield district and to Wales are reported; whilst customers abroad are showing more disposition to extend operations. Nothing under 101*s.* 6*d.* is now named for this year's delivery of Nos. 1, 2 and 3, at which figure both home and export transactions have occurred. Sales of mixed Nos. over the first quarter of 1924 are reported at 102*s.*, and 102*s.* 6*d.* is asked.

Foreign Ore.—Inquiries for foreign ore show some improvement and values are stiffening. Good Mediterranean kinds are in the neighbourhood of 21*s.* 6*d.*, and best rubio is quite 23*s.* 6*d.* c.i.f. Tees.

Coke.—Durham blast-furnace coke is stronger. Good medium qualities are selling at 38*s.* 6*d.* to 40*s.* delivered to local consumers.

Manufactured Iron and Steel.—Conditions in finished iron and steel are healthier than for a long time past. Many firms have good order books, and inquiries circulating are still heavy with the result that values are very fully maintained. Among the principal market quotations are:—Common iron bars, 12*l.*; iron rivets, 14*l.*; packing (parallel), 8*l.* 10*s.*; packing (tapered), 11*l.* 10*s.*; steel billets (soft), 9*l.*; steel billets (medium), 10*l.*; steel billets (hard), 10*l.* 5*s.*; steel boiler plates, 13*l.*; steel strip, bridge and tank plates, 9*l.* 15*s.*; steel angles, joists and heavy rails, 9*l.* 10*s.*; fish plates, 12*l.* 10*s.*; black sheets, 14*l.* 5*s.*; and galvanised corrugated sheets, 19*l.* 5*s.*

Oil Switch Failure on an Electric Train.—The remarkably good record which has been established by the 6,500-volt electric train equipments on the Brighton section of the Southern Railway is illustrated by the fact that the first reported accident due to this equipment, since the starting of the service in 1909, took place only on July 11 last, and that even this first accident was of a trivial character. An explosion took place in the motor-man's compartment of a train in service which was standing at London Bridge Station. Two of the windows of the compartment were broken, and also one of the windows of a passenger train standing alongside. This was the only damage beyond the slight bulging of the door of the high-tension compartment. The explosion, which was apparently due to vapour formed in the oil-switch tank, was traced to a broken high-tension insulator which had apparently allowed arcing to earth to take place. In view of the excellent record of these insulators and switches it might be suggested that the accident fell into the class of those of an exceptional nature which are not likely to be repeated. Major Hall, who investigated the matter for the Ministry of Transport, did not treat the matter too seriously, but suggested that the type of insulator which has a deep recess at its lower end should be replaced by a type already in use on the railway, with a shallow recess. The idea of this is that the packing of the cement and litharge and glycerine, which holds the internal conductor, might possibly crack the unsupported end of the insulator either during assembly or owing to expansion due to high temperature.

Deterioration of Concrete by Seaweed.—A case of deterioration of a ferro-concrete girder, apparently due to the action of sulphur compounds in the seaweed, is reported by Dr. W. T. Cooke, of Adelaide University, in the Journal of the Society of Chemical Industry of November 9. Heavy caissons of ferro-concrete were to be sunk on to the sea bottom of white sand in which posidonia weeds grow. The project was not carried out for other reasons, and one girder remained lying on the seashore for over four years. There is much seaweed on the shore, which, rotting, evolves sulphuretted hydrogen, and the temperature in the sun may rise to 150 deg. F.; there was, moreover, possibility of contamination by sewage. The examination of the concrete showed that it had blackened to a depth of about ½ in., the inner portions remaining unchanged and white, by contrast. The blackening was confined to the cement proper; the boundary between the black and whitish portion was marked by a Liesegang band, indicating the infiltration of some substance. The black portion was fairly hard, though less hard than the inner cement; close to the Liesegang band it proved soft and disintegrated, however, so that evidentally re-cementation had taken place in the outer crust. The black portion contained sulphur as sulphide and sulphate, and more insoluble residue and less lime than the white portion. The sulphide formed by the sulphuretted hydrogen had probably disintegrated the cement, and the lime had then been leached out as Lorenz and Hägermann observed.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

The Trade Position.—The resumption of work in the shipyards this week has given a fillip to general business, and quite a healthy tone now prevails all round. It has not been translated into actual dealing to any great extent as yet, but buyers are more disposed to place orders, and during the past few days not only have inquiries been more numerous but a number of contracts have been fixed up. The one thing which is holding things back a bit is the political situation, but when the air is cleared on December 6 we will then know where we stand, and how to act. For the present, however, uncertainty prevails, and there is great diversity of opinion on the all-important question of tariffs. Shipbuilders have a fair amount of work on hand, and now that delivery dates can be approximately given there is a possibility of more contracts being fixed in the near future. The general trade of this district is sure to improve steadily and unemployment to become much less, but no very appreciable difference is likely before the turn of the year.

Scottish Steel Trade.—There has been rather more doing in the Scottish steel trade during the past week, and producers are hopeful that this will continue. Ship plates and sections are being ordered more freely and the fall in prices has been responsible to some extent, although much of the improvement is due to the settlement of the shipyard dispute. The black sheet makers have lately been in receipt of more orders for the heavier gauges, but the demand is still a long way behind the possible output. In thin sheets there is quite a considerable business passing—much of it on foreign account. Prices are steady and the following are the market quotations :—Boiler plates, 13*l.* per ton ; ship plates, 9*l.* 15*s.* per ton ; sections, 9*l.* 10*s.* per ton ; and sheets, 12*l.* 10*s.* per ton, all delivered Glasgow stations.

Malleable Iron Trade.—The state of the malleable iron trade of the West of Scotland is much better this week, but expansion is slow. Makers will benefit by the resumption of work in the shipyards and employment at the works has already improved. Altogether, the outlook is more encouraging. For re-rolled steel bars the demand continues very satisfactory and quite a lot of work has recently been booked. Prices keep steady, and "Crown" bars are quoted at 12*l.* per ton, delivered at Glasgow stations.

Scottish Pig-Iron Trade.—The improvement in the general outlook is being rapidly translated to the Scottish pig-iron trade and makers report a decidedly better demand for iron. Although more furnaces have not yet been rekindled there is the prospect of that being done at the beginning of the year, but for the present the stocks on hand and the current output would seem sufficient for the immediate requirements of consumers. Prices have been stiffening up and some sellers are asking more than those generally quoted. With the improved demand for steel there is more business passing in hematite iron, and steelmakers are fairly well covered for the present owing to their foresight in placing orders during the past few weeks. Foundry grades are in better request again, but there is much room for improvement. The following may be taken as the current quotations :—Hematite, 5*l.* 5*s.* per ton, delivered at the steel works ; foundry iron No. 1, 5*l.* 8*s.* 9*d.* per ton, and No. 3, 5*l.* 3*s.* 9*d.* per ton, both on trucks at makers' yards.

Wages in the Iron Trade Decreased.—Mr. John M. MacLeod, C.A., Glasgow, has made the following intimation to Messrs. James C. Bishop and Owen Coyle, joint secretaries of the Scottish Manufactured Iron Trade Conciliation and Arbitration Board : "In terms of the remit I have examined the employers' books for September and October, 1923, and certify that the average net selling price brought out is 12*l.* 2*s.* 1·15*d.* per ton." This means that there will be a decrease in the wages of the workmen of 2½ per cent. on basis rates.

ELECTRIC BABBIT HEATER.—According to *Canadian Machinery*, the Volta Manufacturing Company, Welland, build an electric furnace for which they claim many advantages over oil and gas furnaces, more particularly in convenience, the elimination of noxious fumes and the reduction of fire hazard. The cost of operation is also stated to compare very favourably with other furnaces. The makers state that with a charge of 50 lb. of babbit in the pot, the metal will be ready for pouring in 1 hour and 25 minutes, and once the pot is heated 100 lb. per hour may be melted. The furnace is readily transported to any part of a plant.

EARTHQUAKE DAMAGE TO JAPAN'S COTTON INDUSTRY.—Despatches, dated September 18, from the Acting Commercial Secretary, British Embassy, Tokio, give estimates of damage done by earthquake and fire to the Japanese cotton industry. It appears that some 970,000 spindles out of 4,338,000 were put out of action. Of these about 239,000 were entirely destroyed, 360,000 crumbled and the remainder partly damaged. More than half the spindles destroyed, crumbled and partly damaged were for counts between 30's and 42's. Approximately 20 per cent. of the spindles in the country were affected by the disaster. The damage to weaving machines is not great, apart from 300 looms belonging to one company. The larger proportion of the spinning mills destroyed was engaged upon the finer counts, and consumed a comparatively large amount of American cotton. Some 50,000 bales of raw cotton are stated to have been destroyed, of which 20,000 bales were at Yokohama and 15,000 at Fukagawa. The Government has suspended the import duties on cotton yarns and piece-goods.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—The question of the continuation of the third shift for the shipment of coal at the South Wales ports is at present occupying the chief attention of traders. With the coal market much firmer, as a result of heavy chartering and a free arrival of tonnage of late, the docks are becoming congested, and this week there has been a daily waiting list of between 25 and 30 steamers. As loading operations are expected to be active for the next few weeks at least colliery owners, exporters and shipowners view with alarm the resolutions of the men not to continue third shift working after the expiration of the experimental period which ends on Tuesday next. A joint meeting of the local committee has already given the question consideration, but as no official communication had been received by the employers from the headquarters of the men's unions no progress was made, and the meeting was adjourned until after the general election. The question is therefore left in a state of uncertainty. It is believed that the trimmers will continue to work the night shift pending the opening of negotiations, but the position of the tippers is obscure, as it is reported that they are determined to bring the third shift to an end. At yesterday's meeting of the Cardiff Chamber of Commerce, Mr. C. L. Clay, the president, said that now the third shift had been partially re-instituted it would be a great calamity if it were withdrawn. Negotiations had been going on for a long time between the shipowners and coalowners for an improvement in the scale of loading hours for steamers. Subject to the continuation of an effective third shift the coalowners were willing to meet the case of the shipowners quite liberally, and it would be a great pity if these negotiations fell to the ground. Mr. H. J. Heath, of the Coalowners' Association, instanced cases that had occurred at his own collieries of the benefit of the third shift, and said that at times like the present when business conditions necessitated that all operations should be carried out with the maximum of efficiency, it would be unfortunate for a system, which had been introduced, and which more or less had the effect of enabling local facilities to be worked at their full extent, to be done away with. They heard from the men that additional dock facilities were required, but they should make the fullest possible use of the existing facilities, and not until available facilities were utilised to the utmost should the need for a new dock arise. Mr. W. T. Gould, speaking for the shipowners, said that unofficially the men's leaders had admitted the necessity of extra hours being worked. Eventually the following resolution was unanimously adopted : "That this Chamber is strongly of the opinion that the continuation and extension of the third shift at the South Wales ports is absolutely essential in the interests, not only of the coal and shipping trades, but of the general body of workers, especially in view of the serious unemployment in the district." Meanwhile in consequence of an improvement in the arrival of tonnage the coal market has firmed up materially, and there are now few weak spots. Best Admiralty large coal is steady at 28*s.* to 28*s.* 6*d.* with seconds from 27*s.* to 27*s.* 6*d.*, and the leading Monmouthshires from 25*s.* 6*d.* to 27*s.* Best steam smalls are very scarce and firm round 20*s.*, with the ordinary grades from 16*s.* 6*d.* to 18*s.*, and inferiors from 14*s.* up.

Iron and Steel Trades.—Exports of iron and steel goods from South Wales last week amounted to 13,800 tons, or about half the previous week's total. Tin and terne plates amounted to 4,966 tons compared with 10,547 tons, black plates and sheets to 5,654 tons, against 9,540 tons, galvanised sheets to 820 tons against 475 tons, and other iron and steel goods 2,372 tons against 5,836 tons.

ARGENTINE OIL.—The review for October issued by the London and River Plate Bank, Limited, states that the July production of mineral oil in Argentina is put at 39,750 cub. m. (8,745,000 gallons), and is the largest production in any one month to date. From January 1 to July 31 the yield is given as 226,908 cub. m. (about 50,000,000 gallons), which must be considered decidedly satisfactory. The Ministry of Agriculture is reported to be preparing an official scheme for the intensive use of the oil. The feeling is growing in favour of private industry being granted a much freer hand in the matter of boring, and one well-known Argentine banker is said to have published a very frank opinion in the press, wherein stress is laid on the urgent need for encouraging as many interests as possible to carry on the uncertain, if frequently lucrative, expenditure of capital funds which boring for oil must always imply.

THE CANADIAN MINERAL OUTPUT.—According to *The Canadian Engineer*, an increase of over 26,000,000 dols. is shown in the value of mineral production in Canada for the first six months of this year, as compared with the same period in 1922, our contemporary quoting from a report by the Dominion Bureau of Statistics. The value of the output for the first half of this year was 87,152,248 dols., and for the same period of last year 60,361,109 dols. One of the outstanding features of the industry this year was the recovery in the production of nickel and copper, with the reopening of the refineries operated by the International Nickel Company, and the British American Nickel Company. This has resulted in the production of nickel in the first six months of this year being nearly seven times greater than that of the same period of 1922, while the copper output in the first six months this year was greater than that for the whole of 1922. Gold and silver production was maintained at about the same level as in the corresponding period of 1922.

NOTICES OF MEETINGS.

THE INSTITUTION OF AERONAUTICAL ENGINEERS.—Friday, November 30, at 7.30 p.m., at the Royal Society of Arts, John-street, Adelphi, W.C. 2. Lecture, "The Result of Twelve Years' Welded Tube Construction and the Developent of Cantilever Wings," by Mr. A. H. G. Fokker.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, November 30, at 7.30 p.m., at 39, Victoria-street, S.W. 1. Lecturette, "Notes on Design of Paraffin Motors," by Mr. Stratford C. Saunders. Friday, December 7, at 7.30 p.m. Visit to the Lighting Service Department of the British Thomson-Houston Company, 15, Savoy-street. Lecture and Demonstration on Modern Methods of Electrical Illumination.

THE ROYAL SOCIETY OF ARTS.—Monday, December 3, at 8 p.m. : Cantor Lecture, "Recent Progress in the Wool Industries," by Mr. Aldred F. Barker, M.Sc., Professor of Textile Industries, The University, Leeds. (Lecture I.) Wednesday, December 5, at 8 p.m. : Ordinary Meeting, "The Work of the Royal Botanic Gardens, Kew," by Mr. Arthur William Hill, M.A., Sc.D., F.R.S., F.L.S., Director of the Royal Botanic Gardens, Kew. Mr. Charles Albert Seward, M.A., F.R.S., F.G.S., F.L.S., Professor of Botany at the University of Cambridge, will preside. Friday, December 7, at 4.30 p.m. : Indian Section, "The Archives of the Honourable East India Company," by Mr. William Foster, C.I.E., Historiographer, India Office. (Sir George Birdwood Memorial Lecture.) The Right Hon. Viscount Peel, G.B.E., Secretary of State for India, will preside.

THE INSTITUTION OF CIVIL ENGINEERS, NEWCASTLE-UPON-TYNE ASSOCIATION.—Monday, December 3, at 7.30 p.m., at the Lecture Theatre, Neville Hall, Newcastle-upon-Tyne. Paper by Mr. J. E. Parker, Assoc. M.Inst.C.E., on "Water, its Characteristics, Impurities and Purifications."

THE SOCIETY OF ENGINEERS.—Monday, December 3, at 5.30 p.m., in the Apartments of the Geological Society, Burlington House, Piccadilly, W., "Railway Surveying by Photography," by Mr. J. W. Gordon.

THE INSTITUTE OF TRANSPORT.—Monday, December 3, at 5.30 p.m., in the Lecture Theatre of the Institution of Electrical Engineers, Victoria-embankment, W.C. 2, when a paper will be read on "Railways of To-day and To-morrow," by Mr. C. Travis (Member). The chair will be occupied by the president, Sir Joseph G. Broodbank.

THE INSTITUTION OF THE RUBBER INDUSTRY.—Monday, December 3, at 8 p.m., in the Kelvin Room of the Engineers' Club, Coventry-street, W., Major V. Lefebure will read a paper, entitled "Accelerators."

THE BRADFORD ENGINEERING SOCIETY.—Monday, December 3, at 7.30 p.m., Lecture in the Hall of the Technical College. Mr. J. E. Hills, on "Air Lift and Turbine Pumps for Deep Wells."

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—Tuesday, December 4, at 7.30 p.m., in the Rankine Hall, at 39, Elmbank-crescent, Glasgow. Discussion on paper entitled "Pipe Bending by Machinery," by Mr. Carl R. H. Bonn. A paper entitled "The Board of Trade and Merchant Shipping," by Mr. Frank R. Blair, will be read.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, December 4, at 6 p.m. Paper to be submitted for discussion : "The Bio-aeration of Sewage," by Mr. Arthur John Martin, M.Inst.C.E. Students' Meeting, Wednesday, December 5, at 6 p.m. : The first of two Vernon-Harcourt Lectures on "River Training and Maintenance Works," by Mr. Ralph Frederick Hindmarsh, M.Inst.C.E. Informal Meeting, Wednesday, December 12, at 7 p.m. Subject for discussion, "The Lighting of Factories," to be introduced by Mr. Walter Paul Frederick Fanghaenel, B.Sc., and Mr. William Newton Booth, B.Sc., Assoc.MM.Inst.C.E.

THE INSTITUTION OF HEATING AND VENTILATING ENGINEERS.—Wednesday, December 5, at 7 p.m., at the Engineers' Club, Coventry-street, London, a Lecture entitled "Vacuum Steam Heating" will be given by Mr. A. J. Assheton (Member).

THE INSTITUTION OF ELECTRICAL ENGINEERS ; WIRELESS SECTION MEETING.—Wednesday, December 5, at 6 p.m., "The Relation between Damping and Speed in Wireless Reception," by Mr. L. B. Turner, M.A. (Member).

THE NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Friday, December 7, at Bolbec Hall, Newcastle-upon-Tyne, "The Influence of Propeller Revolutions upon the Propulsive Efficiency of Merchant Ships," by Dr. Ing. K. Schaffran.

THE INSTITUTION OF MECHANICAL ENGINEERS : ERRATUM.—In our report of the discussion which took place on the 16th inst., on the "Possibilities of Mercury as a Working Substance in Binary Fluid Turbines," an error appeared on page 643 *ante*, half-way down the third column, where "the heat transmitted in the case of a pure steam plant" given as 1,450 B.Th.U. per kilowatt-hour should read 9,450 B.Th.U. instead.

THE JUNIOR INSTITUTION OF ENGINEERS.—On account of the General Election the meeting announced for Friday, December 7, 1923, at the Royal Society of Arts, has been postponed to Wednesday, January 16, 1924, at the same hall ; Sir J. Fortescue Flannery, Bart., M.Inst.C.E., will then be inducted President of the Institution in succession to Captain H. Riall Sankey, C.B., C.B.E., R.E. (Retired), and will deliver his address, "Marine Propulsion During Fifty Years."

LIGHT STEAM ROAD ROLLERS AT THE PUBLIC WORKS EXHIBITION.

(*For Description, see Page* 671.)

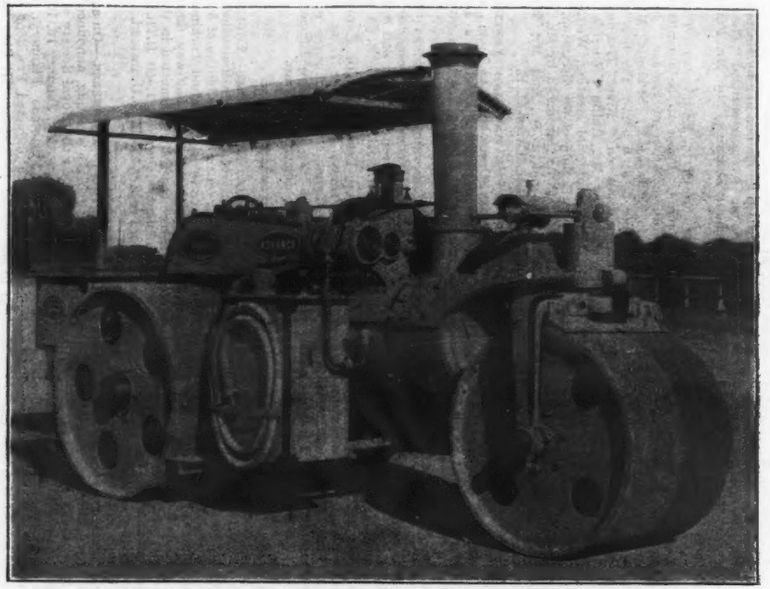


FIG. 21. 6-TON "ADVANCE" STEAM ROLLER; MESSRS. WALLIS AND STEEVENS, LIMITED, BASINGSTOKE.

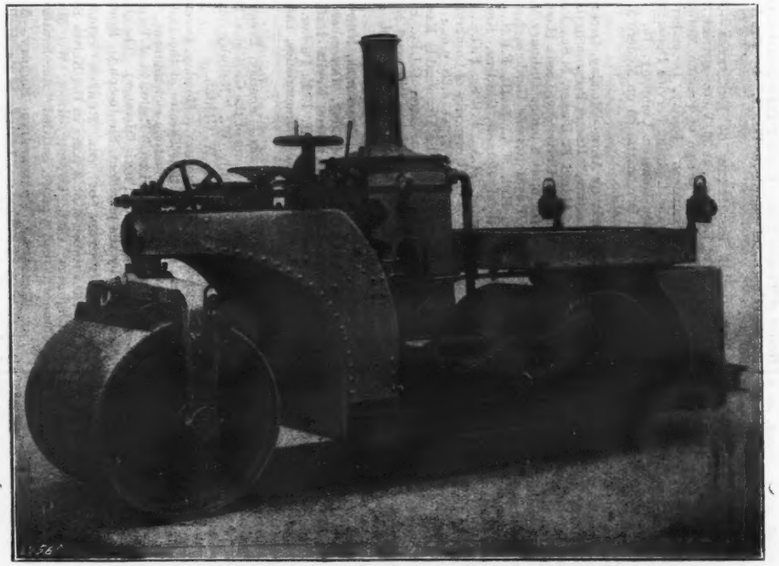


FIG. 23. MILLARS-MARSHALL TANDEM ROLLER; MESSRS. MARSHALL, SONS AND CO., LIMITED, GAINSBORO'.

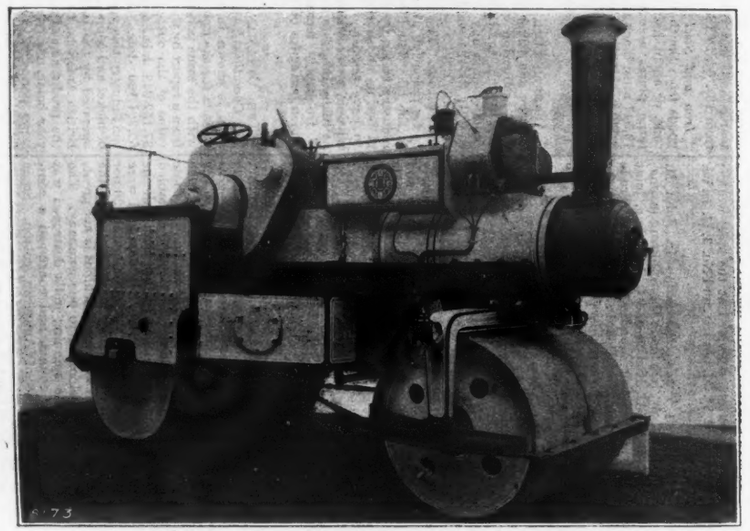


FIG. 22. TANDEM STEAM ROLLER; MESSRS. SIR W. G. ARMSTRONG, WHITWORTH AND CO., LIMITED, OPENSHAW.

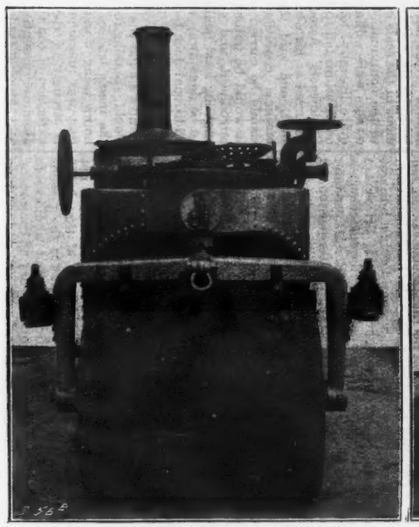


FIG. 24. MILLARS-MARSHALL ROLLER; REAR VIEW.

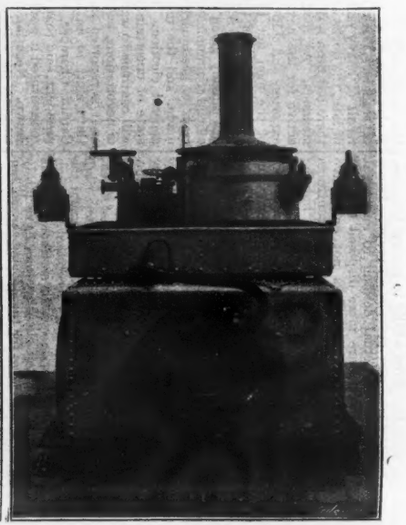


FIG. 25. MILLARS-MARSHALL ROLLER; FRONT VIEW.

FIG. 22. TANDEM STEAM ROLLER; MESSRS. SIR W. G. ARMSTRONG, WHITWORTH AND CO., LIMITED, OPENSHAW.

FIG. 24. MILLARS-MARSHALL ROLLER; REAR VIEW.

FIG. 25. MILLARS-MARSHALL ROLLER; FRONT VIEW.

2-TON VULCAN COMMERCIAL MOTOR VEHICLE AT OLYMPIA.

CONSTRUCTED BY THE VULCAN MOTOR AND ENGINEERING COMPANY (1906), LIMITED, SOUTHPORT.

(*For Description, see Page* 690.)

Fig. 15.

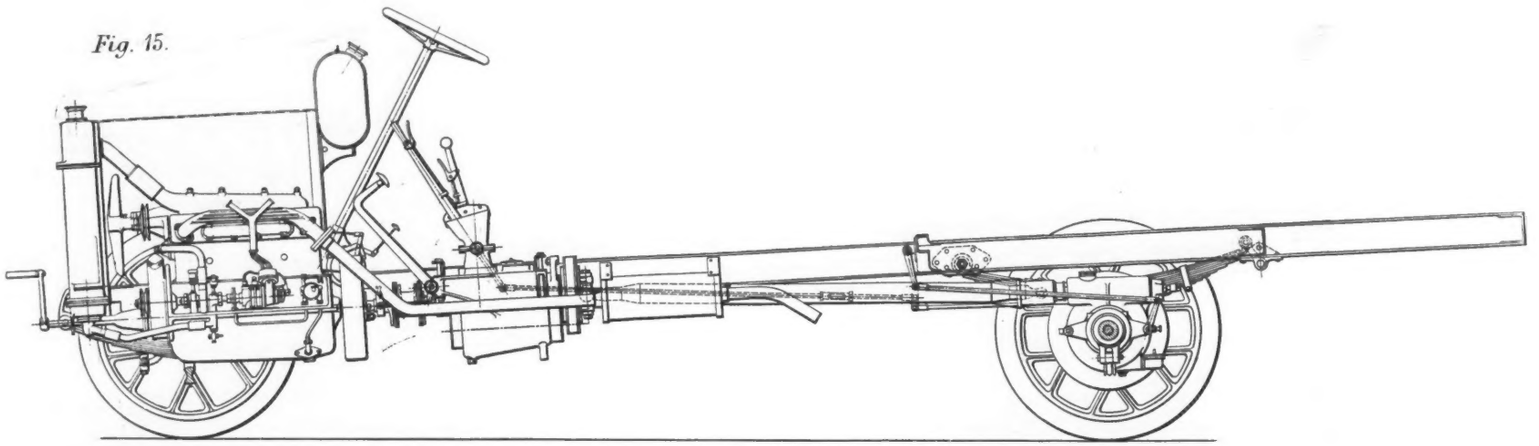


Fig. 16.

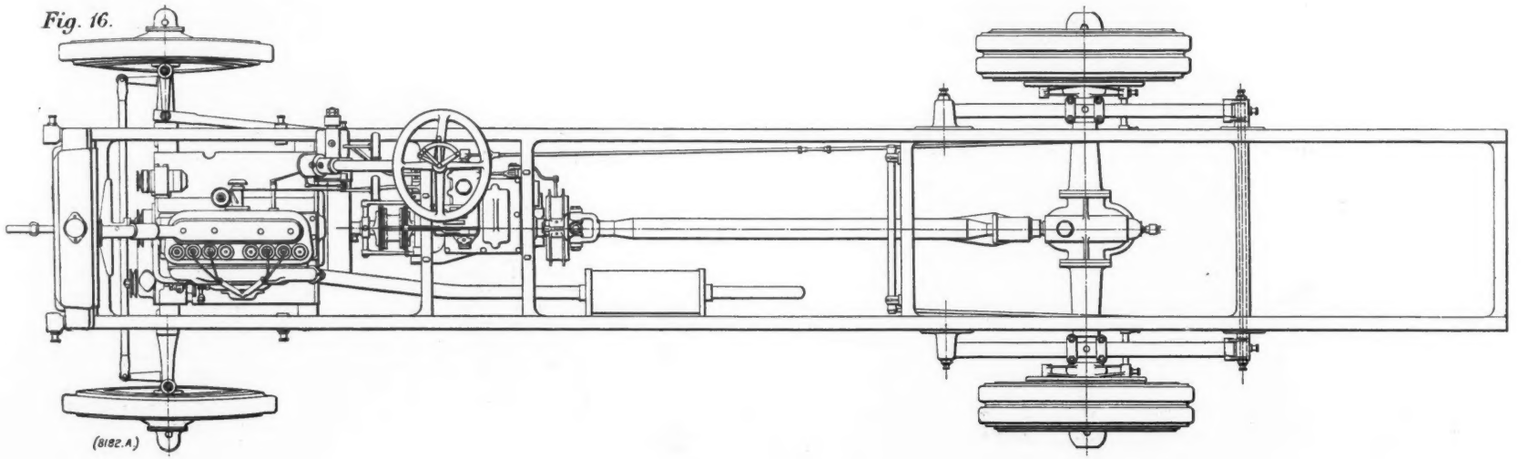


Fig. 17.

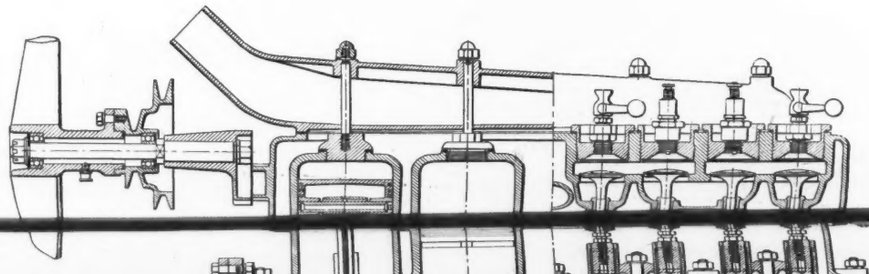
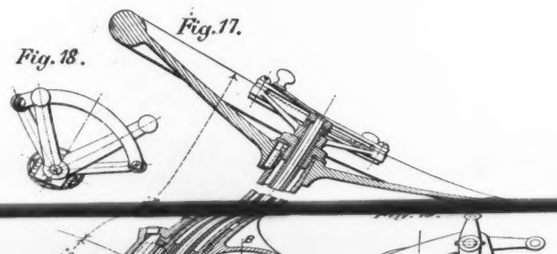


Fig. 18.



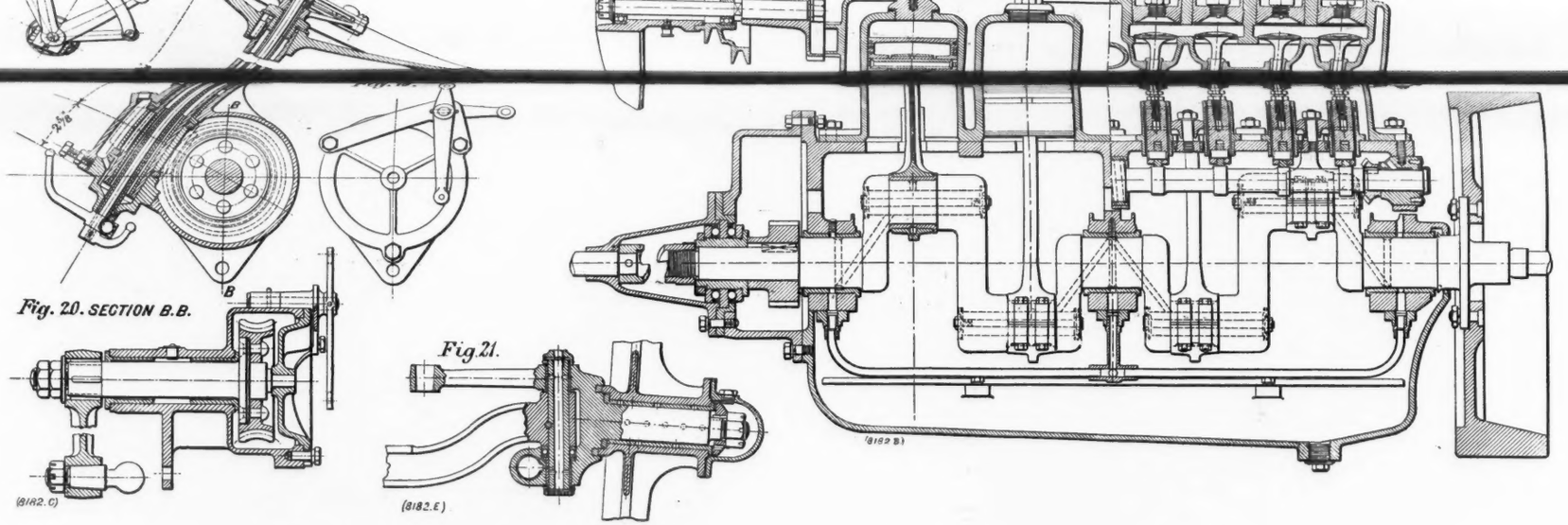


Fig. 20. SECTION B.B.

(8182.C)

Fig. 21.

(8182.E)

(8182.B)

Fig. 24.

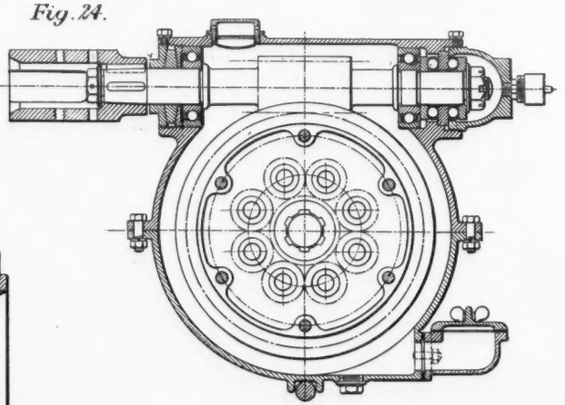


Fig. 25.

SECTION A A .DUST SHIELD REMOVED

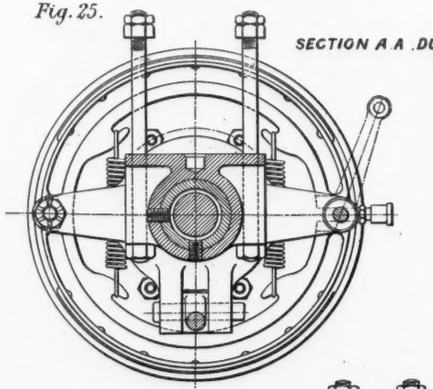
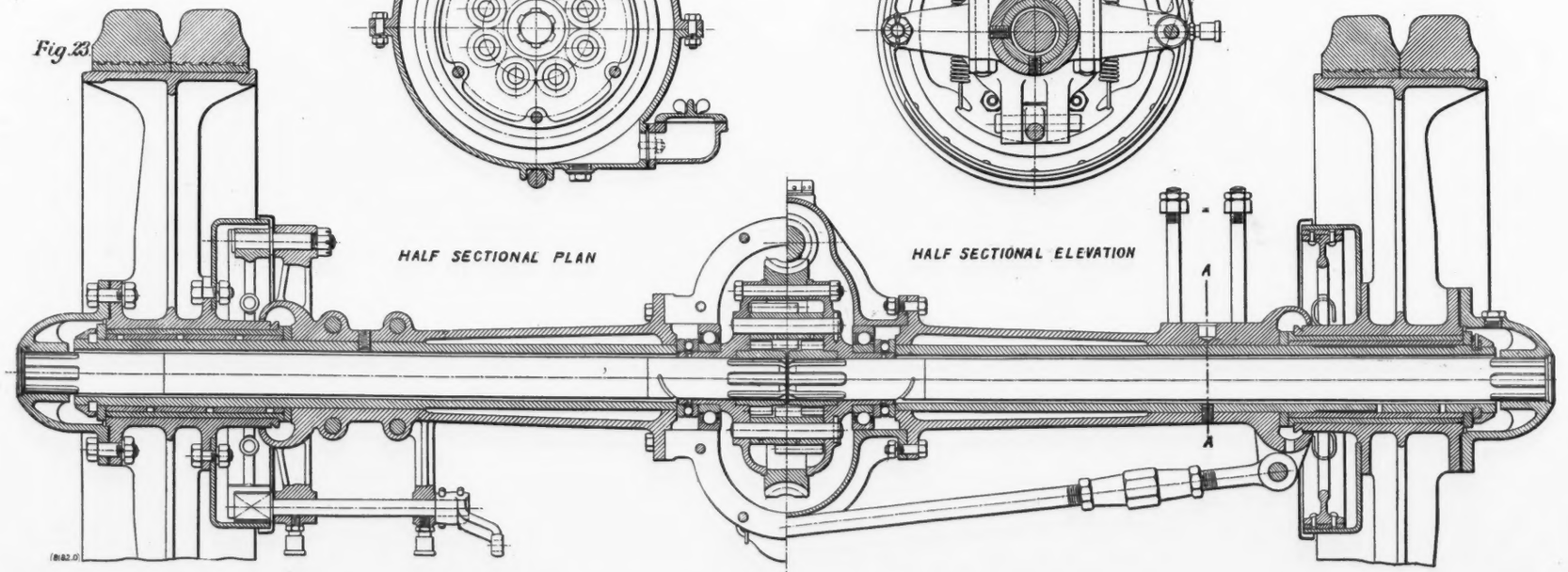


Fig. 23



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Two-Page Plate.—2-TON VULCAN COMMERCIAL MOTOR VEHICLE AT OLYMPIA.

ENGINEERING.

FRIDAY, NOVEMBER 30, 1923.

STRESS AND STRENGTH.

It is probably inherent in the very nature of things that the natural philosopher should continue to be buoyed up by a belief in the innate simplicity of Nature and her laws. As a matter of history, however, this hope has been systematically disappointed, and Nature has appeared to be simple only so long as we have not pushed our studies beyond certain limits of accuracy. The great generalisation of universal gravitation enormously simplified theoretical astronomy, but so soon as really precise measurements became possible, doubts began to be thrown on its universal validity. We have accordingly been offered instead the doctrine of relativity which, however effective in accounting for the minute discrepancies between observation and calculation, can hardly lay claim to assent on the basis of its simplicity. Again, there are probably few nowadays who would assert that the great principle known as the conservation of energy is more securely based than Newton's hypothesis. The principle has held so far up to the limits of our measurements, but it will ever be impossible to prove that it holds indefinitely. Nevertheless, these simple working hypotheses have proved, and will continue to prove, invaluable for all ordinary purposes, and it is much to be desired that we could get some equally effective law correlating stress and strength.

As matters stand, the more thoroughly this problem is investigated the more complex does it appear, and it is not a little remarkable that the trend of much recent work has been to show that the endurance of a material is more intimately associated with its ultimate strength than with its elastic limit. The whirligig of time brings in here a notable revenge on the theoretical elasticians of the last generation who poured out the vials of their scorn on the engineer who persisted against, as they affirmed, all the rules of logic in basing his working stresses on the ultimate strength of a material instead of on its elastic limit. Any number of good arguments could be advanced in favour of the latter standard, particularly as amended by James Thomson's concept of the elastic range, which subsequently formed the basis of Bauschinger's most important work. Nevertheless the investigations made at the engineering experiment station of the University of Illinois, as described in a recent report,* indicate that it is the ultimate strength of ferrous metals and not their elastic limits which fixes the endurance of the material. Strong confirmation of this conclusion is afforded by the behaviour of our old railway bridges, as to which some highly instructive data were brought forward at the Hull meeting of the British Association last year. An extremely interesting description of the methods adopted in proportioning these old structures has been given by Mr. J. S. Wilson and Professor Haigh, in their contribution to this year's report of the British Association's Committee on "Complex Stress."

At the date at which these bridges were erected stress analysis had been little developed, but our pioneers adopted the truly scientific, if costly, plan of proportioning their structures on the basis of experiments on models. As stated, the method was costly, and it is accordingly not surprising to learn from Fairbairn that many weak bridges were being built in which first principles were disregarded, and some such step as that taken by the Board of Trade about 1859 was probably inevitable. In fixing a working stress of 5 tons per square inch as permissible on wrought iron the Board of Trade engineers probably thought that they were taking a step in advance, but as Fairbairn pointed out no distinction was made between live and dead loads, and this led to a refusal to pass one of Fairbairn's bridges, which subsequent experience has shown must have been amply proportioned for the loads he had designed it to carry. The dispute had at least one beneficial effect, as it led to a series of experiments on repeated stress, carried out by Fairbairn in the early "sixties," which thus antedate by some years the better-known experiments of Wöhler.

Mr. Wilson has done good service in republishing some particulars of this research. It was made on a built-up girder of some 21 ft. span, 16 in. deep, and about 6½ in. width over flanges. A notable point is the high bearing stress carried by the rivets, which was as much as 21·3 tons per square inch. It is probable that experience with pin-connected trusses had some effect in leading to the much lower limits of bearing stresses which found their way first into American specifications, and subsequently into our own. Pins are necessarily loose in their holes, and as a consequence the nominal maximum bearing stresses are increased by a greater concentration of the load and also perhaps by the hammering due to vibration, which the tightly-fitting rivet escapes. Here no doubt is to be found the explanation of the little trouble experienced as a consequence of the high bearing stresses admitted by the early designers. For example, from the instructive analysis of the stresses on Brunel's bridge at Chepstow, which Mr. Graham Gribble gave in our issue of February 21, 1902, it appears that the bearing stress on the rivets amounts to some 13 tons per square inch, yet there has been no trouble from loose rivets in spite of the loads carried being much in excess of those contemplated at the erection of this bridge in 1851.

As already observed some such move as that made by the Board of Trade was probably inevitable. The Board had to take the responsibility of passing railways for traffic, and had therefore to fix some standard of reference even if only to avoid constant debate and dispute. A rigid rule is, in fact, of enormous advantage to a public department, and in this case the rule laid no excessive burden either on the engineers or the railway shareholder, even although the logic of the argument lay with Fairbairn rather than with the Board of Trade.

The rule involved, however, some disadvantages, in that it tended to obscure the real function of a bridge, which is to carry safely certain specified loads. At one time it almost seemed as if some designers considered the object in life of a truss was to have its stresses calculated, and the merits of different designs were no longer settled by a comparison of their behaviour under traffic, but by the ease and certainty with which the stresses could be predicted. More and more the engineer seemed to believe that the important point was an agreement between calculated and observed stresses.

* An investigation of the Fatigue of Metals Series of 1922. By H. F. Moore and T. M. Jasper. Bulletin No. 136. Published by the University of Illinois. Price, 50 cents.

In some instances indeed the existence of an undetermined or indeterminate stress became nearly as disturbing to his peace of mind as is the report of uncharted rocks or reefs, to that of the master mariner. Experience gave little warrant for this nervousness which, however, at one time led to the plan of hinging compression chords at every joint so as to eliminate the secondary stresses at these points.

This futility, however, did not long survive the test of service, but in spite of this record many engineers of to-day still profess misgivings as to the danger of uncalculated secondary stresses. So far as our observations go, however, in no case have they based their fears on the records of experience. This, indeed, seems to indicate that generally speaking, a statically indeterminate structure which appears to be safe under any plausible distribution of stress will be so in actuality. In this is to be found the justification for Rankine's treatment of the double latticed truss, which he regarded as equivalent to a pair of single-latticed trusses, each taking half the load. Many bridges were proportioned on this hypothesis, and gave very satisfactory service.

It is probable that when the stresses are of the alternating type the above rule may no longer be valid, but the experiments of Mr. Wilson and Professor Haigh described at Hull last year do indicate that it holds in the case of a pulsating stress, which does not change sign but only alters in magnitude. They pierced a steel specimen with a very small hole, and subjected it to a stress of the above-mentioned type. According to the mathematical theory of elasticity the stress at the edges of this hole was three times the average, yet the endurance proved to be practically the same as that of unperforated comparison bars.

In the case of alternating stresses there seems a better accord between theory and practice, but even here, some peculiarities have recently been noted of which no satisfactory explanation has so far been forthcoming. It must be nearly fifty years since it was shown in Lord Kelvin's laboratory, that a steel wire could be "trained" to carry a load which would cause failure if applied without this preliminary procedure. Thus a wire which in its original condition would break under a load of 45¼ lb., was left under a load of 43 lb. for 24 hours. At the end of this time a load of 49¼ lb. was required to break it, and in subsequent experiments this figure was gradually increased to 57¼ lb. These were static tests, and the observations did not seem to require any very recondite explanation.

It has, however, now been found that somewhat similar results can be observed under alternating stresses, and of this no ready explanation suggests itself. Attention was drawn to the matter at Hull last year by Dr. A. A. Griffith, and his statements are confirmed by those of the American observers as set forth in the report we have already referred to. Specimens which had borne 100,000,000 cycles without failure under stresses just below the endurance limit were re-tested, and bore without failure 50,000,000 alternations of a stress which was higher than the original endurance limit of the material. In one case (a 0·37 carbon steel) the excess was 20 per cent.

ROAD REFORM.

In political conflicts we are of course prepared for, and almost expect, the misrepresentation of our cause by our opponents. As engineers, however, in our professional capacity we expect a more level-headed consideration of the *pros* and *cons*, and though enthusiasm may tempt us to paint in rather glowing terms some pet idea to which we have become committed, we leave these embellishments as a rule to the commercial man who ultimately gets a footing in so many enterprises. As an example of the frame into which we do not mind throwing ourselves we may instance the paper read some time ago before the Institution of Automobile Engineers by Mr. C. le M. Gosselin, himself the manager of a fleet of steam wagons, on the subject of "The Use and Limitations of the Steam Wagon." The author wisely accepts the limits of the machine, and, as his experience has proved, has been able within this sphere to develop a satisfactory business.

Mr. Gosselin has now followed this paper up with a more general discussion of the "Advantages and Limitations of Road Transport," having made a contribution on Wednesday last on this subject to the Road Traffic Conference being held at Olympia, in connection with the Commercial Motor Transport Exhibition. In this latter paper the author has unfortunately departed somewhat from the standard which we would like to see maintained. Nearly all the advantages named are to accrue to the nation, being of the semi-philanthropic order, and intended to raise the standard of living among the masses. This is all very well so far as it goes, but road transport concerns are not run merely to benefit by a reflection of national conditions. Such enterprises are embarked upon as everybody knows and admits, because it is anticipated that they will be rewarded with profit—only when State undertakings are advocated can persuasion be based upon other lines. This, however, is a minor matter, and most people will probably forgive the author for his omission to mention this obvious point.

When we come to the "limitations" we are afraid that the author's feelings have hardly been sufficiently restrained. The limitations quoted are a few of them mechanical, but the majority are disadvantages which Mr. Gosselin argues the transport concerns are compelled to suffer owing to the backward state of the country in realising what a boon this particular industry might become if properly cherished. We have often referred to unique features of road transport which entitle it to a permanent position in our internal economy, to say nothing of the vital necessity of being prepared for international and other complications. Opinions differ, however, as to how far we have actually failed in connection with this industry. Mr. Gosselin states that for twenty-five years the users of the roads have been improving their methods, but that the same cannot be said of the road authorities, many of whom have shown gross neglect of their plain duties, &c. If, instead, of reading this to an audience mainly composed of motor users, the author had made these statements before the Public Works, Roads and Transport Congress, which closed yesterday at the Royal Agricultural Hall, Mr. Gosselin would not have had the argument quite so much his own way. The cause for our backwardness, if we admit such, is not in the "incompetency" of our road authorities, as Mr. Gosselin well knows, but is much further to seek. The road authorities have no need to shelter themselves behind the excuse that "to-day's requirements have been sprung upon road surveyors as a surprise." That we agree is ridiculous, but the suggestion that they are to blame for not heeding the "initial warnings" of 1820, is in very much the same category.

Who are these surveyors? Perhaps it is more to the case to say who they are not. They certainly are not, as one might be led to imagine, officials intended primarily to make the road fit for any user, at any cost, nor are they clever enough to make limited funds balance with extremely heavy expenditure. They are servants of public bodies—not free agents, and these public bodies have in the past had very restricted resources. It is quite true that in recent years the traffic has been too severe for the roads, but this can be explained quite apart from the incompetency of the authorities. Long before the war engineers were interested in and experimenting with systems which they hoped would meet the case. Possibly if the war had not supervened these developments would have fairly kept pace with the increasing use of mechanical vehicles. They certainly kept pace with the funds available. Even in those days public money was expended on investigations at Bushey, but the road vehicle made a satisfactory solution well-nigh impossible by the retention of steel tyres.

As we all know, during the war, expenditure on roads was cut to a minimum. Labour was withdrawn for the Front, and these factors, with the exigencies of supply of munitions, did more to ruin the conditions of our roads than years of normally expanding traffic. At the close, with the roads in bad condition, and the "incompetent" authorities handicapped by low funds, excessively high costs and poor labour, and thousands of surplus and reconditioned vehicles thrown upon the highways, driven by men used to rough going abroad, the well-nigh hopeless task was begun of putting the roads in order, not to the standard of 1914, or even of a normal 1919, but in the face of tremendous odds which no motor engineer even would have dreamt of a few years before.

We hear a deal in these days about fair treatment and competition. That this onslaught on the roads by mechanical transport was grossly unfair is proved by the large number of mushroom transport concerns which flourished while war savings and gratuities lasted, but which have since gone out of existence.

In spite of all, we know that the condition of the roads has been greatly improved, though we do not suggest that all is now well. Far from it—much remains to be rectified. Taking things all round, however, the road transport industry has been treated with considerable generosity. Mr. Gosselin claims that the roads ought to be made fit for the 90 per cent. of the traffic passing over them rather than for the small balance. There is little doubt that they could, and would, if the mechanical transport industry footed 90 per cent. of the bill involved in putting and keeping them in order. At present they pay less than half the cost of upkeep, and it is mainly due to the nation generously subsidising the industry, and to the unemployment relief schemes having been further directed to the advantage of the motor vehicle, that the recent improvements have been made. With all this we think some little gratitude to the country for its help might reasonably be expected of the motor vehicle users.

There is no doubt that much is being done for the industry. Many think it is being unduly favoured when most other concerns have to stand on their own feet. We agree, however, with Mr. Gosselin in his desire to see conditions still further improved and important roads brought under responsible bodies and officials. If there is one thing which has prevented the maintenance of a uniform standard on our main roads, it is due to sections being controlled by small councils, unable to afford large reconstruction schemes, or even pay a good salary to their surveyor. Here it is not the surveyor who is at fault, but the system, and it would be an immense advantage if all important roads were placed under the care of a few responsible authorities such as the counties, who can employ first-class engineers and whose works are on a scale to render the use of machinery, so essential nowadays, economically possible. Such reorganisation would help to bring things forward and result in considerable saving.

ENGINEERING SCHEMES IN PARLIAMENT.

A QUARTER of a century back the November *Gazettes* were crowded with proposals for private Bills relating to various schemes *d'intérêt public*, the normal contents of these publications being reduced to an insignificant fraction of the total. A vastly different state of affairs is met with to-day. The notices *re* bankruptcy proceedings and the winding-up of companies are exceptionally numerous, whilst schemes for further and better development of our natural resources are few and far from striking. This is the more remarkable in view of the efforts being made to reduce the volume of unemployment. In part, however, this is due probably to the fact that public companies are able to do a good deal without seeking further Parliamentary powers. No doubt the financial situation is in part responsible, but even before the war the unfair treatment which Parliament too frequently meted out to really meritorious proposals had done much to discourage enterprise, and the unintelligent rejection two or three years ago by the House of Lords of plans for developing water power in Scotland was not calculated to re-establish confidence.

RAILWAYS.

All the great railway groups are promoting Bills this session, but very little is proposed in the shape of new extensions. Nevertheless the companies are

undoubtedly intending to spend very large sums in the immediate future in betterments and improvements. Most of these, however, unfortunately for the lawyers, can be effected under their existing powers. Hence the Bills give no indication of the important electrifications now in progress or to be undertaken shortly, and, of course, the companies have long enjoyed a free hand as regards additions to rolling-stock and the like.

The London Midland & Scottish Bill seeks sanction for widening their Market Harborough–Leicester line for a distance of 1¾ miles near Kibworth Harcourt; whilst in Derbyshire 1½ miles of widening are proposed at Staveley, and rather over 2 miles at Bolsover. On the other hand the Bill provides for the abandonment of a number of lines of which the construction has been authorised in previous sessions. Amongst these is the Clayton Moor Light Railway, for which powers were secured in 1912. By another clause powers are taken to abandon the Church Road Station at Birmingham. The new works notified include the construction of a new road at Chadderton, in Lancashire, whilst the bridge over Prestatyn Station, in Flintshire, is to be lengthened. In Norfolk the company propose to reconstruct the bridge which carries the Martham–Great Yarmouth road over the line at Hemsby.

The most important works referred to in the Bill promoted by the Southern Railway are directed to the improvement of the docks at Southampton. Here it is intended to construct some 3 miles of embankment, walls and jetties, and to lay out two new graving docks. At the same time the channel is to be deepened by dredging. Other dock work includes an improvement of the Medina Wharf, in the Isle of Wight. Quite a number of short lengths of line are to be constructed in Surrey, most of which are apparently junctions or station improvements. Thus the Bill provides for the construction of over ¾ mile of new line at Wimbledon, and a length of 5·8 chains at Sutton. Powers are also sought for 1 furlong 5 chains of new line at Leatherhead, and for 1 furlong 8 chains at Dorking. Platform extensions are foreshadowed at the Elephant and Castle and at Brixton. Here also the viaducts are to be widened simultaneously. Bridge widenings are also to be undertaken at Lewisham and Forest Hill. In another clause powers are sought to abandon the existing line between Ramsgate and Margate Sands. Powers are further taken for acquiring the undertaking of the Wimbledon and Sutton Railway and for winding up that company.

A new company is promoting a Bill for the construction of 7½ miles of new railway between Chichester and Selsey. A curious clause in this Bill is one authorising the operation of the line by any motive power other than electrical.

The London and North Eastern Railway provide in their Bill for two widenings at Islington, each over ⅛ mile long. At Bethnal Green Junction the existing line is to be widened for a distance of nearly 6½ chains. At Stepney a widening of nearly ⅜ mile is intended. But the heaviest work provided for is at Poplar and West Ham, where one widening will extend for over ½ mile, and another over 1¼ miles. Another widening in the Metropolitan area is that contemplated at Wood Green, which will be 1 furlong 3·8 chains in length. In the provinces quite a number of improvements are proposed. In Lincolnshire, widenings will be made near Lincoln, and also on the line to Grimsby, in the Scunthorpe and Frodingham district, for a total length of about 1½ miles. The Newark to Mansfield Railway is to be widened for a distance of over 3 miles in the Southwell area. At Howden, in the East Riding, the Selby to Hull line will be widened at Howden for a length of 2¼ miles. Other works include the abolition of the Thurgoland Tunnel, in the West Riding, and of the two tunnels at Hattersley, in Cheshire, which are all to be converted into open cuttings.

The Great Western Railway Bill provides for the construction of a branch from Stourbridge to Kinver, and for the extension of the existing railway from Pwllheli to Abersoch. Powers are also taken for the construction of a junction between the Rhymney and Taff Vale lines at Cardiff. A short extension of the Cornwall Mineral Railway near St. Austell is also provided for. One clause in the Bill is worth noting, as illustrating how past generations of lawyers in Parliament have succeeded in restricting the freedom of the railway companies in quite trivial matters. This clause authorises the company to substitute a card index for the shareholders' address book.

Though much has been heard of the activities of the London Underground Group, their Bill merely seeks powers for the construction of additional subways at Bond Street Station.

An independent Company is promoting a scheme for developing a wharf at West Thurrocks, Essex, by constructing railway lines giving access to the metals of the London, Tilbury and Southend Railway.

Light Railways, Tramways, Trolley Lines and Motor Buses.

According to a familiar quotation, "Coming events cast their shadows before," and it is to be hoped that the proposal by two corporations, viz., those of Croydon and St. Helens, to abandon certain of their existing tramlines in favour of more modern forms of transport, foreshadows the day when these anachronistic abominations will vanish from our streets. Glasgow and London are the worst offenders. In the former city the obstruction due to the admission of the trams into the central part of the city has caused an intolerable congestion where the north and south lines and east and west lines intersect. Falstaff claimed to be not merely witty in himself, but the cause of wit in others, and similarly the tramcar, in reducing the traffic capacity of the roads they physically obstruct, are also the cause of congestion on other routes. The new lines now proposed by the Glasgow Corporation have an aggregate length of about 5 miles, but appear to be mainly in substitution for existing lines, so that possibly the City Fathers are gradually realising the unwisdom of further commitments *re* their transport speculation.

In London fortunately the tramcars have not so far been allowed free access to the City, but the L.C.C. are making a further attempt in this direction in their new Bill, in which powers are sought to carry the rails over Southwark Bridge. In one respect, however, the London trams are worse than those in Glasgow, as the conduit system introduces what in effect is a third rail, of a particularly objectionable character. The Council propose to lay new lines in Lewisham and Woolwich along the Bromley road, and to extend their lines in West Norwood to the Crystal Palace Parade.

At Manchester some 6 miles of tramways extensions are proposed, and a good deal of similar work is to be undertaken at Birmingham and at Hull.

The Southport Corporation propose to construct about ¾ mile of new line in extension and improvement of their tramways undertaking. Trolley services are proposed by the Corporations of Croydon and St. Helens, and also by the London United Tramways Company to serve Twickenham and Teddington. Other promoters desirous of developing this type of transport are the Corporations of Rotherham and Ashton-under-Lyme. Powers to run motor 'bus services are sought by the Corporations of Dover, Harrogate and Rawtenstall.

Electricity.

The most important Electrical Bills are three promoted by the London companies for the constitution of a joint authority for the metropolitan area. We shall deal with this scheme at length in an early issue, and need not therefore enter into particulars here.

There is an extraordinary dearth of applications for new electric lighting orders, due perhaps in part no doubt to the present uncertainty as to the role to be played by the super-station. The North Metropolitan Electric Power Supply Company seek to extend their limits to Hitchin, Baldock and Royston, and to Bishop's Stortford. Other undertakings seeking similar extensions are the Oxford Electric Company and the Clyde Valley Electric Power Company. In Scotland a provisional order is sought for Crieff, in Perthshire. It may perhaps be added that the Crewe Corporation are to take a supply of electricity from the railway company's power station.

Water Supplies.

The Thames Conservancy is promoting a Bill which makes stringent provisions for minimising the pollution of the Thames and its tributaries; and the Brighton Corporation is another authority which seeks additional powers for preventing contamination. The Southend Water Company proposed new impounding works on the Chelmer at Rushes Lock, and on the Blackwater at Langford Cut. Incidentally they are taking powers to divert sewage. It is proposed by certain local authorities in Staffordshire to take over the undertaking of the Staffordshire Potteries Waterworks Company, and to administer it by a joint board. The Bailsdon Urban District Council have a Bill authorising the construction of a new reservoir at Bingley, to impound water from the Horncliff Beck, the Weecher Brow Beck, the Cocklake Well and White Flush. The Manchester Corporation seek powers for enlarging Lake Thirlmere. New impounding reservoirs on the River Rydon and Bogden Clough are proposed by Wakefield Corporation, whilst that of Hastings is desirous of obtaining additional water supplies from wells at Battle. The Corporation of Tynemouth propose to augment their supply by new intakes from springs at Cartington. Scotch proposals include a Bill promoted by the Burntisland Corporation for a new reservoir in Dour Burn, together with subsidiary works, and also an enlargement of the Cullaloe reservoir. In Midlothian it is proposed to unify under the County Council or a district board a number of independent supplies in the Calder district.

Miscellaneous.

The London County Council are seeking powers to reconstruct Lambeth Bridge. Another important new bridge proposal is that put forward by the Flint County Council for a new bridge across the Dee at Queen's Ferry. At Birkenhead the Corporation is seeking to be relieved from the obligation undertaken in 1897 to maintain a ferry service between New Ferry and Liverpool.

Some extensive street widenings are proposed by the L.C.C. in South-Eastern London. The Leicester Corporation are also seeking powers for work of a similar character, as is in their turn the Corporation of Haslingden. The Morecambe Corporation propose to widen and extend their promenade and to construct a new street along the shore. The works will involve ⅛ mile of embankment. Somewhat similar proposals are tabled by the local authority at Penarth. Other towns seeking sanction for street widenings are Manchester, Leeds, Birmingham, Hull, Rotherham and Hastings.

An important proposal is the establishment of a Mines Drainage Commission for South Yorkshire, which will be equipped with somewhat far-reaching powers.

In view of the extravagant claims not infrequently made as to the utility of British canals, it is of interest to note that the Urban District Councils of Aberdare and Mountain Ash propose to take over the Aberdare canal and part of the Glamorganshire Canal. A portion of the former is to be converted into a main road.

The Conservators of the Malvern Hills, where Piers the Plowman had his summer morning's vision 500 years ago, are taking steps to further protect the amenities of the district, and in particular to regulate the quarrying of stone.

TRADE MARKS.

It is not generally realised among inventors, particularly among engineers, and to a certain extent among chemists, that valuable rights can be obtained by the registration of appropriate trade marks and monopoly positions set up subsidiary to those obtained by patent protection and sometimes of more use. It has been said that the principle of granting monopolies is not sound. This may, or may not, be so, but the point is that while monopolies are granted it is idle not to take advantage of them. A piece of apparatus or a chemical process may be protected by a patent. That patent under the present law gives to the patentee the right for sixteen years from the date of the patent application to make, use, exercise and vend the invention as a sole right. The bargain with the Crown is that he shall so inform the public how to carry the matter into effect that at the expiry of the patent they

may be enabled to do this for their own benefit if desired.

Assume now that the apparatus patented is supplied to the public under a particular name, as is often the case, valuable rights attach to that name. At the end of the patented period probably the name has become very well known, and even with the free competition which exists after the patent has run its life the inventor of the original article still has in a sense an advantage in that the article covered by a patent is commonly asked for by the name by which it was originally known.

If there be no rights protecting this name it may be employed by others, and therefore no advantage would accrue to the patentee by its use. It is true that no one would be allowed to pass off, say, by means of the name or otherwise, goods of their manufacture as and for goods of the patentee's manufacture. That is a Common Law right which cannot be taken away.

On the other hand there is no monopoly right in the name. If, however, the latter has been registered as a trade-mark and properly used there is no reason why valuable monopoly rights in the name should not subsist after the patents have expired. The Trade Marks Acts at the present time recognise two different classes of marks, the second-class having only recently been added.

The first class, known as Part A of the Register, in addition to comprising all trade marks previously registered, covers those which might have been registered under the main act, that is to say, the name of a company or the like represented in a special manner, a signature, an invented word or words or a word having no direct reference to the character or quality of the goods, not being a geographical name or a surname.

The second class of marks, forming Part B of the Register, deals with marks which have been *bona fide* used in the United Kingdom for not less than two years in connection with any goods for the purpose of indicating that they are the goods of the proprietor by virtue of manufacture, selection, certification or the like. The real criterion in this case is whether the mark is what the public looks for as indicating origin.

If a trade mark is registered to protect a word which the patentee uses, or intends to use, in connection with a patented article, it must be very carefully employed if it is to fulfil the object intended. It is well settled law that if a mark is simply the word by which the public knows a patented article that mark ceases to have any monopoly rights. This is indeed specifically provided for in the Trade Marks Acts according to which where in the case of an article or substance manufactured under any patent in force a word trade mark registered is the name or only practicable name of the articles or substance so manufactured, all rights to the exclusive use of such trade mark, whether under the Common Law or by registration shall cease upon the expiration or determination of the patent and thereafter such word shall not be deemed a distinctive mark.

The Act is particularly clear in connection with chemical substances, for it provides that no word which is the only practicable name or description of any single chemical element or single chemical compound as distinguished from a mixture shall be registered as a trade mark.

Inventors of apparatus frequently try to invent a new name for such, and at the same time to obtain a patent covering the apparatus. If they use such a word as to bring the public to the state that they invariably attach the word to the apparatus to indicate the apparatus and not the origin of its manufacture, no valid registration can be secured, and therefore no effective monopoly rights obtained in the word.

Assume an ammeter were a new piece of apparatus and that the word ammeter were registered as a trade mark. Assume also that a patent had been obtained covering all current measuring devices, and that these were called ammeters. At the expiry of the patent if such apparatus were commonly known as ammeters the registration of the mark would not give any rights to the patentee. On the other hand if the patent specification and trade literature made it quite clear that only current-measuring apparatus supplied by the patentee could be given the designation of the term ammeter, but otherwise such apparatus was known as, say, a current measuring instrument or an ampere ammeter, then assuming that the word came within the definitions of a registrable trade mark and be registered, the word ammeter would solely apply to instruments made by the patentee long after the expiry of the patents. Similar remarks apply in the case of chemical substances.

Monopoly obtained by means of a trade mark is a very elusive quality, and must be carefully watched to see that the words do not lose their distinctiveness by becoming words denoting articles as opposed to words denoting the origin of articles. A trade mark is not in the nature of a substance existing by itself, but is rather an attribute. It cannot be assigned of itself, but only with the goodwill of the business in the goods.

RAILWAY ELECTRIFICATION IN FRANCE.

Although, as a result of recent legislation, active steps are being taken towards a better standardisation of electricity supply voltages and periodicities in this country, there is little evidence of any activity of the same kind in the matter of railway electrification. A standard system was certainly recommended by an influential committee, but there is little evidence that anyone has taken very much notice of it. A very different state of affairs would appear to exist in France, where a Commission decided in 1920 on a standard system which was to be accepted by all the French railway companies. The standard specifies a three-phase, 50-period, primary current for distribution and 1,500 volt direct-current traction, with either an overhead conductor or third rail. In exceptional cases, 3,000-volt direct-current may be used with an overhead conductor. At the time this standard was introduced the Midi Railway Company had a large amount of single-phase railway in operation, or in course of equipment, notably the 70-mile line between Pau and Montrejeau with 63 miles of branch lines. On the introduction of the direct-current standard system all this single-phase work was abandoned and an immediate commencement was made towards a conversion to the new standard. Much of the work has now been done, and the first 1,500-volt direct-current locomotive appeared on the Pau-Tarbes division at the end of 1922.

The total electrification work which is projected by the Midi Railway to be carried out during the next ten years amounts to nearly 2,000 miles. This ambitious programme, which is energetically being pushed on, will give the Company one of the greatest, if not the greatest, electrified system in the world. The lines of the Midi Railway traverse the southern part of France from the Atlantic Ocean to the Mediterranean. They connect Biarritz and Perpignan and serve most of the valleys on the north side of the Pyrenees. The lines also run north of Beziers across to Cévennes district, which is wild and mountainous. The major part of the whole area served by the company is of a very hilly character, and as a result, very steep gradients are not uncommon, there being quite a number of over 1 in 33. These conditions make the lines difficult and expensive to work with steam locomotives, and in view of the fact that ample water power is available in the area, it is a matter of no surprise that the question of electrification has long been under consideration.

The first electrification work was undertaken by the company in 1902, when a narrow gauge-line, 35 miles long, from Villefranche-de-Conflent to Bourg-Madame in the Eastern Pyrenees, was put in hand. The line climbs to a height of 5,000 ft. and involves long gradients of 1 in 16 with curves of 200 ft. radius. Direct-current at 850 volts, with a third rail was employed. This line was opened in 1910. Later, the single-phase work to which we have already referred, was undertaken, the system used being single-phase, 16 periods with 12,000 volts on the contact wire. This work made considerable progress, and when it was interrupted by the war, 30 motor cars and 24 electric locomotives were ordered. Some of these have since been converted to use 1,500-volt direct-current which has become the new standard.

A considerable amount of detailed information bearing on the work which is now being done, was given in a paper by M. A. Bachellery, Chief Engineer of the Midi Railway, which was read by the author before a joint meeting of the Institution of Electrical Engineers and the British Section of the Société des Ingénieurs Civils de France on the 22nd inst. The lines to be electrified present very diverse features, and include level main lines carrying fast passenger and heavy goods traffic, branch lines to watering places to which the traffic is of a partly suburban character and mountain lines with very steep grades, while one of the most interesting pieces of information given by M. Bachellery was that the company have succeeded in limiting to four the number of types of locomotives which will be required to handle the very diverse traffic. The designs for the four types have been got out by the company's engineers in association with the Société des Constructions Electriques de France and the English Electric Company.

It is of great interest to note that in none of the four types of locomotive adopted has a side-rod drive been used, although this type of drive has been generally associated with Continental practice. The first two types are passenger and freight locomotives similar to each other except for the gear ratio. They are mounted on two four-wheel motor trucks, each of the four axles being driven by a geared nose-suspended motor of 250 h.p. The total weight of each locomotive is 72 tons, and the maximum speeds are 55 miles an hour in the case of the passenger locomotive and 40 miles per hour in that of the freight locomotive. These latter machines on mountain lines can haul a 185-ton train up a gradient of 1 in 25. A rear locomotive will normally be used to assist a train on the worst grades. Altogether 90 locomotives of this class have been ordered, and 13 are already in commission.

The third type of locomotive is more properly described as a motor coach. It is intended for suburban and branch-line services, and is carried on two four-wheel bogies of the swinging bolster type. Each of the four axles is driven by a series nose-suspended 125 h.p. motor. The motors are wound for 750 volts and are connected two in series. The coach is built of steel and has accommodation for 48 passengers seated and 32 standing. It weighs 52 tons and has a maximum speed of 50 miles an hour. It is considered that these three types of machine will be able to haul any kind of train either on mountain or level lines at speeds up to 50 miles an hour. For higher speeds a special type of express locomotive has been designed which is still of the geared type, but entirely suspended motors and a quill drive have been employed. The engines are of the 4-6-4 type. The driving wheels are 69 in. in diameter, while the adhesive weight is 54 tons and the total weight 102 tons. The three centre axles are each driven by two motors, and the end bogies are practically identical with steam locomotive bogies. The six motors are each of 375 h.p., one-hour rating, giving 2,250 h.p. for the whole machine. They are wound for 500 volts and are connected three in series. The maximum speed of the locomotive is 75 miles an hour. It will be noted that these engines are of symmetrical type, and in view of the controversy that has arisen in connection with such a construction, it is interesting to hear from M. Bachellery that the machines behave well at high speeds. He attributes this to the fact that they have a rigid wheelbase of 13 ft., which keeps them steady on the track, have trucks elastically centred through side springs and a height of centre of gravity similar to that usual in steam practice. We are not sure if M. Bachellery counts his motor car among his four types of locomotive, but in any case it appears that a still more powerful type of express locomotive of 3,200 h.p. is under consideration.

The Midi Railway has at the present time 140 miles of electrically-operated line, but only 37 miles are of standard construction and type. The remainder represents earlier work which is gradually being changed over to the new 1,500-volt direct-current standard. In addition, several hundred miles of line are under conversion. Power is at present supplied from the 21,000 h.p. hydro-electric station at Soulom and a similar 35,000 h.p. station at Eget. Three further stations are being built by the company on the Gave d'Ossau, which will

contain a total of 130,000 h.p. of generating plant. Other power stations are projected in the central and eastern Pyrenees for the time when electrification reaches those districts. Three-phase current at 50 periods is produced at all stations and the standard transmission voltage is 60,000, but 150,000 volts is being used for long distances in certain cases. The step-down transformer substations are in general situated about 15 miles apart, and it is proposed to run out power supply mains for general purposes from these stations, so that, in addition to serving the railway, the scheme will make a general supply available in a district which is not of a sufficiently industrial character to make an independent electric supply commercially possible. The Midi supply scheme will ultimately link up with the schemes of the Paris-Lyons-Mediterranean and Paris-Orleans Railways, which propose to electrify some 3,800 miles of line, while the latter company proposes ultimately to run a 300-mile 150,000-volt transmission line from its Dordogne power station to Paris.

LITERATURE.

The Hydraulic Principles Governing River and Harbour Construction. By CURTIS McD. TOWNSEND, late President Mississippi River Commission. New York: The Macmillan Company. London: Macmillan and Co., Limited. [Price 12s. net.]

A RIVER is the consequence of the conveyance of accumulated rainfall from a higher to a lower level, and exhibits the results of many nicely balanced forces, that throughout long ages have sought a condition of equilibrium. The channel carved out by the constant flow does not always satisfy the necessities of commerce or the demands of industry, and hence arises the desire for improvement. But to interfere with the established order is always hazardous and not infrequently unfortunate. The number of variables that enter into the functioning of a river is large, their relations involved, and their activities uncertain. Each river presents problems peculiar to itself, and the treatment that has proved successful in one case furnishes little guide in suggesting the measures appropriate to another. Generally it may be said, that the obvious is always wrong, a front attack is usually unsuccessful, and the engineer gains his object, or at least effects some portion of the improvement contemplated, by a subtle assault on the flank. The author has had long experience in the training of American rivers, especially the Mississippi, whose long and varied course gives opportunity for trying many devices, and he indicates that too frequently it is the unexpected that happens. He is prepared for any anomalous behaviour in the vagaries of rivers, and while not afraid to express and maintain his own views, admits that uniform practice is not possible or desirable, and that fundamentally different schemes may be urged quite defensibly by engineers, as to the proper method of treatment in involved circumstances.

Colonel Townsend's book, evidently the fruit of much personal experience, should serve three purposes. It introduces the engineer to the general principles that govern the regulation of rivers and indicates the circumstances that make departures from rule necessary; it criticises for the benefit of the expert hydraulic engineer the plans that have been adopted in various countries to secure desired ends, and it satisfies the intelligent curiosity of the unprofessional man, who wishes to be informed of the fundamental principles governing the flow of water in natural channels. It, moreover, urges caution on those who, impressed with the increased facilities for transport that would follow the acceptance of some recommended scheme, fail to grasp the ulterior consequences of pursuing their aim with undue precipitancy.

As an illustration of the complicated character of the problem we may mention briefly the main causes of the variations to which a river is submitted during its course to the sea. The uplands are being continually eroded, and the displaced material in being carried by the current, raising the river's bed by deposit, but not uniformly, while passing through the area of deposition. The effects of the movement along the river's bed form the serious problem that faces the hydraulic engineer. The slopes of the river bed are continually varying, and consequently the rate of movement: the water supply pursuing the path of least resistance gives to the bed a sinuous curve, causing pools to be formed in the bends, and bars in its straight reaches. Streams flowing through valleys formed by glacial action will differ greatly from those that push their way through alluvial soil, by reason of the difference in amount and character of the material carried in solution and suspension by such streams. The inflow of tributaries will introduce changes that may be irregular, or seasonal, but the general effect will be to vary the slope at the point of junction, by the deposition of material in suspension and subsequently to form sand waves which will move along the river bed. Another uncertainty in control will be caused by the prevalence of floods in the upper reaches, and no more difficult problem can be set the engineer than to predict flood heights and their consequences. Navigation and agriculture both look for assistance and both are frequently disappointed. The lives and property of communities in low-lying valleys subject to overflow are seriously threatened, and science looks on hopelessly. Few suggestions for predicting flood heights have proved successful, and it must be remembered that no formula, mathematical or empirical, founded on average conditions, is of the slightest use, for a flood prediction has to differentiate between the exceptional and the average. Neither can it be said that great success has attended the methods devised for protection, whether by storage reservoirs, waste weirs, retarding basins, or other means.

The point to be made is that every river brings its own problem of regulation, and when some method of control has been devised that has diminished the irregularities on an important waterway, the same scheme may fail when applied to what is apparently a similar problem. In early days, the comparatively feeble device of constructing a bank revetment was useful, the main purpose being to secure a firm towpath, suited to horse traction for propelling small barges, and later, when low water depths, not exceeding 3 ft. over gravel bars, sufficed, the construction of parallel dikes on opposite sides of a river gave fairly satisfactory results. But the advent of the steamboat with its ever-increasing tonnage compelled the adoption of more radical methods. Engineers, probably basing their suggestions on the flow of water in pipes and conduits, proposed to give to the river as straight a course as possible, with a uniform slope, in place of a natural sinuous course, with here a gentle slope as the water passed through a pool, and there a steep slope when bars intervened. The plan seems natural and obvious, and only failed because the water was not amenable to the change, preferring to select its course as it had done through past centuries. The river bed deepened and in some cases became so great, that it undermined the restraining revetment, destroying it and precipitating the material into the river, making the last stage of that river worse than the first. Then followed the days when drastic straightening being discredited, improvements took the gentler form of allowing the river to pursue its own meandering course, preserving its alternative slight and steep slopes, but converting poor crossings, where they occurred, into good ones by giving a suitable direction to the river currents across the bars. The river was to be coaxed rather than driven, and the adoption of this system is said to have worked a favourable revolution in river regulation.

The thorough method of straightening was advocated by the Germans, the persuasive plan by the French, and each nation is still inclined to adhere to its own methods. Both are described adequately, instances being given in which improvement has followed the adoption of either course, but the author quite rightly refuses to decide between their respective merits, for conditions occur in river regulation that makes either scheme suitable. Colonel Townsend's caution was perhaps scarcely necessary, but it may be well to be reminded that "river improvement is not susceptible to rigid mathematical analyses . . . Each river has its own equation."

The author recognises and describes with examples four other distinct methods of river regulation, each of which may prove adequate in certain conditions, and in the course of a long river like the Missouri and the Mississippi, all may be profitably employed.

I. Canalisation: effected by constructing a series of dams across the river bed and overcoming the differences of elevation at the dams by means of locks.

II. By dredging and the removal of obstructions, a method that is greatly assisted by the huge dredging plants available in America.

III. By building reservoirs which impound the water during the high stages, and releasing it to fill the river when navigation is impaired owing to deficiency.

IV. By levees, which confine the flood discharge and utilise it to enlarge the low water section.

To the description of each of these methods a chapter is devoted giving much valuable practical information. As a necessary consequence several side issues of a most interesting character are raised, to which it is impossible to refer. But among others will be found discussed, the influence of forests on precipitation, the effect of tidal flow in estuaries, the formation of deltas at river mouths, the work of breakwaters, and in a final chapter that breaks away from engineering practice, the economics of water transportation. We can only call attention to these different items which give a distinct character to the work, but in justice it should be said that a complete survey of an important branch of engineering has been successfully attempted. The book will prove invaluable to those who need to know what has been achieved in the improvement of rivers and harbours. Those of the public who take an interest in applied science will find this treatise one of the most fascinating books that have recently appeared.

Strength and Structure of Steel and Other Metals. By W. E. DALBY, F.R.S. London: Edwin Arnold and Co. 1923. [Price 18s. net.]

SOME four or five years ago the present reviewer had a keen debate with a well-known authority on the Mathematical Theory of Elasticity, concerning the oscillations found in the stress-strain curves of wrought iron and mild steel immediately after the yield point is reached, and before the steady plastic state has been attained. The mathematician, on what appeared to be purely *a priori* grounds, maintained that these oscillations represented no physical reality, but were simply due to the use of a defective testing machine. We have reason for believing that his views on the matter have changed but, if not, a study of the volume under review would, we think, show him that his previous position was untenable, and that these curious oscillations really do correspond to peculiarities in the metal itself. They are never found save in the case of iron and steel, and are not present in all steels.

In the opening chapter of his book, Professor Dalby describes the different forms of testing machine in use. The main interest in this chapter lies, however, in the detailed description given of the author's optical recorder. In this the load is measured by the elastic stretch of a calibrated steel bar, which is caused to tilt a mirror which reflects a fine point of light on to a photographic plate. Interposed in the path of the ray is a second mirror which is tilted by the stretch of the specimen under test. The record taken is therefore free from inertia errors or errors due to pencil friction. With this arrangement, Professor Dalby has, moreover, been able to obtain records under quite novel conditions. In particular, a complete record has been obtained in a test of which the total duration was only 1 second of time. Again it has been possible to obtain records with exceedingly short specimens for comparison with those given by test-pieces of the normal type.

In the next section of the book we have an exceedingly interesting series of these records, the value of which is enhanced by printing below each a micrograph showing the structure of the bar tested. The author explains the peculiarities of these micrographs in detail, pointing out the different constituents. A particularly interesting set are those relating to bright-drawn steel. Here the micrographs, it is pointed out, give no indication that the steel is in an overstrained condition, and

taken *per se* could accordingly afford no clue as to the cause of a failure. The stress-strain curve of this overstrained material differs, however, markedly from those yielded by the same material after annealing being similar to those given by alloy steels or non-ferrous metals. Indeed, in following up this line of work Professor Dalby has succeeded in getting from the overstrained steel, stress-strain curves very analogous to those yielded by tin and zinc. Some of the micrographs are very striking, and special mention should be made of those relating to pig-iron. The concluding chapter of the volume contains an account of work carried out for the British Engineering Standards Association on the strength of screw threads. This showed that in hard steels the threads failed by shear, but that in soft steels the threads "pulled over," bending as cantilevers, until the yield was sufficient to free the bolt.

Professor Dalby's book constitutes a very valuable contribution to our technical literature and will, we hope, be widely read.

BOOKS RECEIVED.

Wireless for the Amateur. By J. Roussel. London: Constable and Co., Limited. [Price 14*s.* net.]

The Metallurgy of Steel. Vol. I. *Metallurgy.* Vol. II. *Mechanical Treatment.* By F. W. Harbord, Assoc.R.S.M., F.I.C., and J. W. Hall, M.Inst.C.E., M.I.Mech.E. Seventh edition, thoroughly revised. London: Charles Griffin and Co., Limited. [Price 35*s.* net, each volume.]

Diesel Engines. By Lacey H. Morrison. First edition. London: McGraw-Hill Publishing Company, Limited. [Price 25*s.* net.]

Mechanics of the Gasoline Engine. By H. A. Huebotter, M.E. First edition. London: McGraw-Hill Publishing Company, Limited. [Price 20*s.* net.]

Boiler Chemistry and Feed Water Supplies. By J. H. Paul, B.Sc., F.I.C. London: Longmans, Green and Co. [Price 14*s.* net.]

Technical Arithmetic. By R. W. M. Gibbs, B.A., B.Sc. London: Blackie and Son, Limited. [Price 3*s.* 6*d.*]

Engineering Mathematics. By R. W. M. Gibbs, B.A., B.Sc. London: Blackie and Son, Limited. [Price 1*s.* 6*d.* net.]

Commonwealth of Australia. Department of Defence. Munitions Supply Board. *Technical Reports,* 1921–22. *The Source and Influence of Impurities in* 80 : 20 *Cupro-Nickel.* By C. Blazey, M.Sc. Melbourne: Albert J. Mullett.

United States Geological Survey. Bulletin No. 689. *Boundaries, Areas, Geographic Centres and Altitudes of the United States, and several States with a Brief Record of Important Changes in their Territory.* By Edward M. Douglas. [Price 50 cents.] No. 709. *Triangulation and Primary Traverse,* 1916–1918. By C. H. Birdseye. [Price 75 cents.] No. 739. *Mineral Resources of Alaska. Report on Progress of Investigations in* 1921. By A. H. Brooks and others. Washington: Government Printing Office.

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Aeronautical Research Committee. Reports and Memoranda. No. 842. *The Production and Heat Treatment of Chill Castings in an Aluminium Alloy* ("*Y*"). By W. Rosenhain, D.Sc., and others. [Price 1*s.* net.] No. 869. *Notes on the Vortex Theory of Airscrews.* By H. Glauert. [Price 6*d.* net.] No. 876. *Lift, Drag and Pitching Moment of the* $\frac{1}{4}$*th Scale Bristol Fighter Model in the Duplex Wind Tunnel.* By E. F. Relf and E. Ower. [Price 9*d.* net.] London: His Majesty's Stationery Office.

THE COMMERCIAL MOTOR TRANSPORT EXHIBITION AT OLYMPIA.

(*Continued from page* 662.)

Messrs. Ransomes, Sims, and Jefferies, Limited, of Ipswich, are amongst the exponents of electric vehicles, which many corporations find particularly economical for the collection of house refuse, as the batteries can be recharged at the municipal generating station at very slight cost during hours of low load. The great mechanical simplicity of these vehicles is attractive, while the nature of their duties which necessitate a moderate speed with numerous stops along good roads and a small radius

5-TON ELECTRIC REFUSE-WAGON AT OLYMPIA.

CONSTRUCTED BY MESSRS. RANSOMES, SIMS AND JEFFERIES, LIMITED, ENGINEERS, IPSWICH.

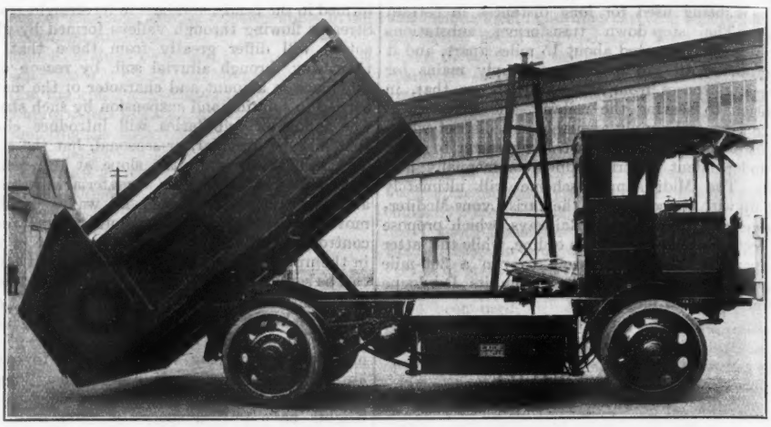


Fig. 6.

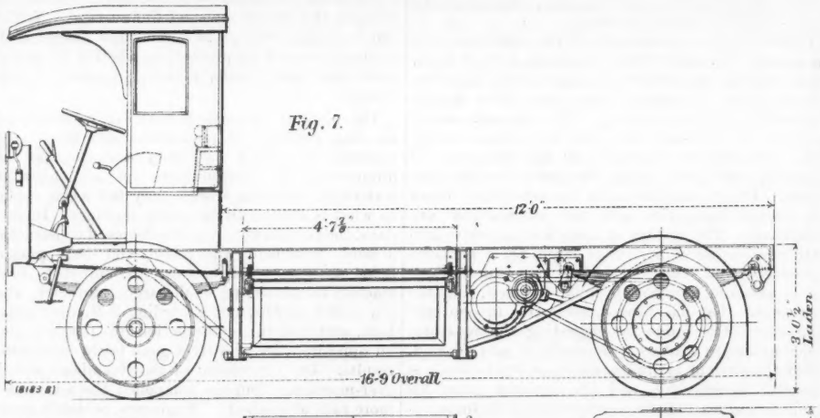


Fig. 7.

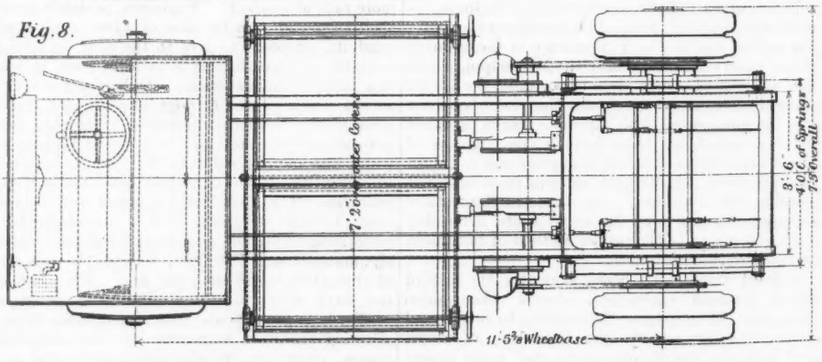


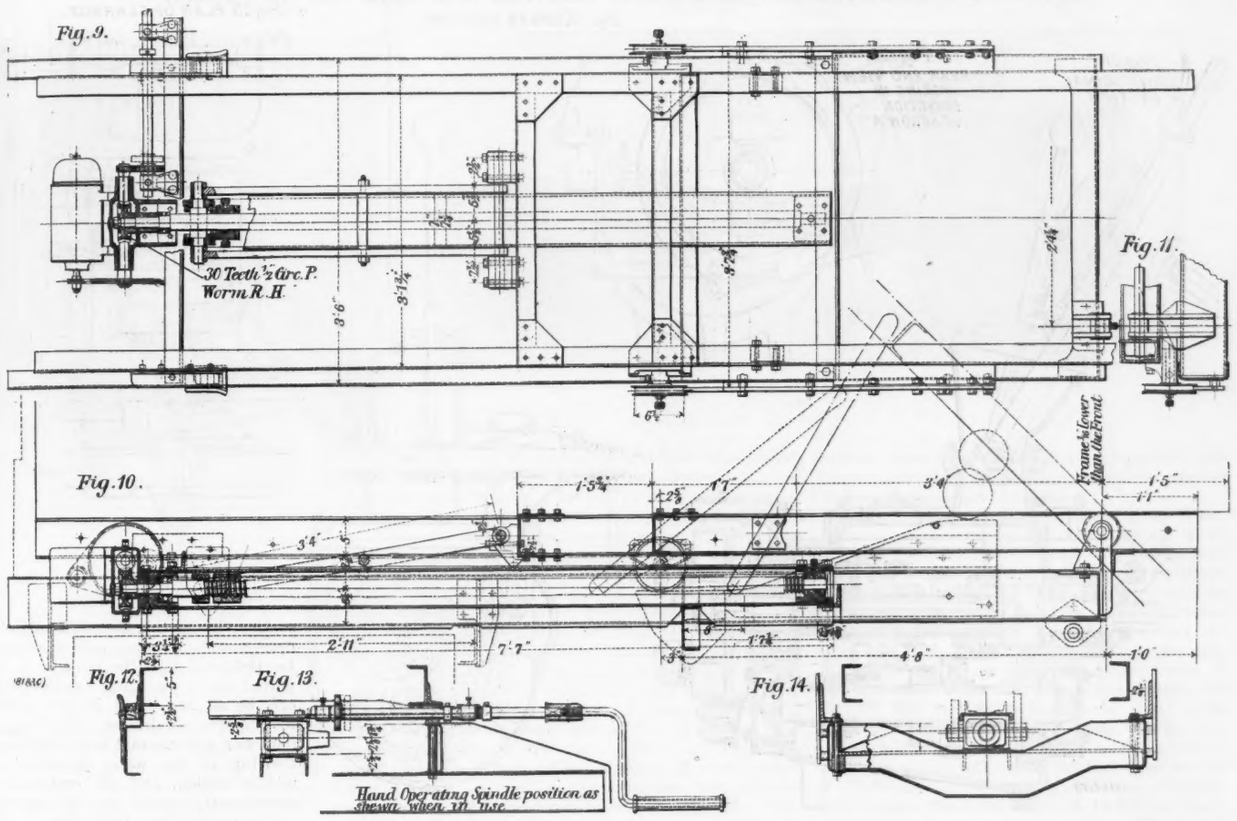
Fig. 8.

of action, is such as to show the type in its most advantageous aspects. The wagon illustrated in Figs. 6 to 14 on the present and opposite pages is designed for a 5-ton net load, and is fitted with tipping gear and a special body to suit the requirements of the Birmingham Corporation. From Figs. 7 to 14 it will be seen that the two driving units are independent. The power of each motor is transmitted by enclosed helical gear to an independent countershaft carrying a chain sprocket, which in turn transmits to a rear road wheel by a roller chain. All bearings are of the ball or roller type throughout. The main controller drum under the driver's seat, is operated by a gate change lever having four forward running and one reverse position. There is also an auxiliary drum controlled by a foot pedal. This pedal must be depressed before passing from one position to another on the main controller, the effect of the action being to insert resistance into the circuit before the current is broken, and thus to avoid sparking at the contacts of the main controller. The operation of the foot pedal is exactly analogous to that of an ordinary clutch pedal. It enables the driver to coast in traffic and to ease off when turning corners, without interfering with the main controller, so that both hands are free for steering or signalling purposes. Steering is by worm and segment gears and the front wheels turn about their points of contact with the road, so that no fault of the road can tend to make the wheels deviate from their set course.

In the chassis illustrated, the frame members are trussed, and the large battery is carried on the compression members. The battery is contained in two separate boxes, mounted on rollers and running in channel iron tracks, so that one man by operating the rack and pinion mechanism can easily move out the batteries for inspection. The wheels are made from pressed steel plate, with cast steel naves to form the housings for the ball and roller

DETAILS OF TIPPING GEAR OF 5-TON ELECTRIC REFUSE-WAGON AT OLYMPIA.

CONSTRUCTED BY MESSRS. RANSOMES, SIMS AND JEFFERIES, LIMITED, ENGINEERS, IPSWICH.



bearings. The wheels are at 11 ft. 5⅜ in. centres, and a 35 deg. lock is obtainable with the steering mechanism. The rear wheels of the chassis shown are fitted with 12-in. solid Dunlop tyres. The tipping mechanism, illustrated in Figs. 9 to 14, annexed, is of the horizontal screw type, with the screw and roller tracks between the side members, so as to give the lowest possible platform level. The nut is connected to the rollers between the tracks by links, thus avoiding any tendency to distort the screwed spindle. A 1·5 b.h.p. motor operates the gear, the drive being by chain and worm gear, the worm wheel being keyed on to the screw itself. Hand operation is also provided for. The tipping gear control switch is automatically returned to its neutral position when the body has reached either its tipping angle or has returned to its normal position.

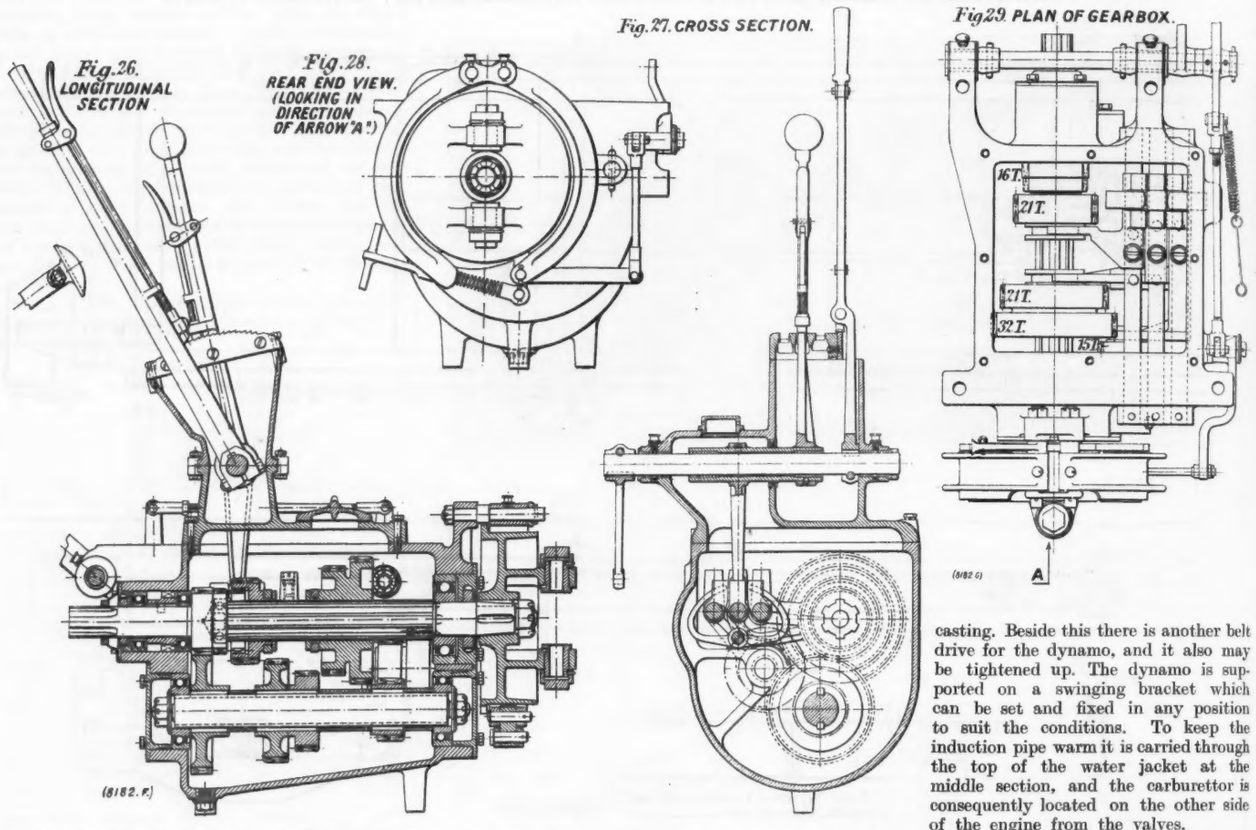
The Electric Steel Castings Company, Limited, of Wentworth chambers, Pinstone-street, Sheffield, are showing steel and malleable iron castings of various kinds for commercial vehicles, but cast steel road wheels form their main exhibit. These are constructed to take solid rubber or pneumatic tyres, a particularly noticeable type being that designed for the giant pneumatics which are now coming into use for fast lorries and char-a-bancs. In this type the wheel consists of a six-armed steel spider with a pair of circular half-rims. The half-rims are put on the tyre and held together by means of six clamps. Each half-rim has around its inner edge six lugs which project inwardly towards the centre. When the rims are held together by the cramps, the pairs of lugs form keying pieces which engage in circumferential slots on the ends of the spider arms. The tyre with its rims on, having been put over the spider and rotated clockwise until the lugs are engaged with the slots, the clamps can be removed and the pressure of the air in the tyre will force the two half-rims outwards and cause them to grip the spoke ends firmly. At the ends of three of the spokes security bolts are fitted to prevent the rim rotating should the tyre become deflated. The whole device seems very sound mechanically and affords a simple means of securing the extremely heavy tyres which are now favoured for fast transport vehicles.

The Albion Motor Car Company, Limited, of Scotstoun, Glasgow, are among the firms exhibiting a 30-cwt. chassis built to War Office specification, and thus capable of earning for its owner an annual subsidy of 40*l.* on consideration of its being placed at the disposal of the Government in times of national emergency. The engine is of the monobloc type with four cylinders and two detachable and interchangeable cylinder heads. The cylinders are 3⅞ in. diameter by 5-in. stroke. The inlet and exhaust valves are on the same side of the cylinders, and the valve tappets are adjustable, the whole of the valve gear being totally enclosed by a detachable cover. The engine is lubricated throughout by a forced feed system, a submerged pump drawing oil from the sump reservoir through a large gauze filter and delivering it under pressure to the three main bearings, whence it passes through drilled holes to the crank-pins. An Albion-Murray governor is fitted to the front end of the crankshaft. This governor makes it impossible for the driver to race the engine, and its setting cannot be tampered with without partially dismantling the engine. The camshaft and magneto shaft are driven from the crankshaft by single helical gears, and the fan and pump spindle are driven by a belt from a pulley on the magneto shaft. Four speeds forward and a reverse are provided, the maximum road speed being limited by the governor under normal conditions to 22 m.p.h. The final drive is by worm and worm wheel. The back axle casing, carrying the worm and differential gear, is a single forging, and the design is such that the wheels can be easily removed from the axle shafts, or the axle shafts themselves withdrawn, if a bad breakdown should render towing necessary. The wheel base is 11 ft. 3 in., the front wheel track 5 ft. 1¼ in. and the rear wheel track 4 ft. 10 in. The front wheels carry giant straight-sided pneumatic tyres, 6 in. by 36 in., and the rear wheels have tyres 7 in. by 38 in. Alternatively beaded cord tyres, single in front and twin in the rear, 895 mm. by 135 mm., are fitted, and with these the ground clearance is 9½ in.

The conditions of running in taxicab service are much more exacting than those of ordinary motoring, and consequently the design must be looked at from the standpoint of the commercial vehicle rather than from that of the touring car. This attitude is not always taken up, and there are many taxicabs in general use to-day which must need frequent overhauls in consequence. Design to suit the police regulations is, of course, essential, otherwise the licence would not be obtainable, but compliance with a set of regulations of that type does not imply, however, that satisfactory running is assured. Strength characteristics and the reliability of the engine are the fundamental matters that must be dealt with by the designer. There has been talk at times of instituting periodical inspections and tests of the London taxicabs in order that old and unsatisfactory machines may be removed from the roads, especially those old cabs that have very unreliable engines. In this field of service, as in every other to which engineering knowledge has been applied, it is essential that the vehicle be built expressly to meet the conditions under which it operates. The firm of Beardmore Motors, Limited, early adopted this outlook, and have, in consequence, earned a very good reputation for the taxicabs they build. These cabs have a four-cylinder engine which develops 22 h.p. at 1,200 r.p.m. In the construction of the crankshaft and other components, as well as in the transmission system, the experience gained in the production of steels to withstand great stresses has been applied. By that means strength has been maintained without making the chassis very heavy. The crankshaft of the Beardmore taxicab is made of heat-treated special aero steel. Liberal dimensions of bearings, which

GEAR-BOX OF 2-TON VULCAN COMMERCIAL MOTOR VEHICLE AT OLYMPIA.

CONSTRUCTED BY THE VULCAN MOTOR AND ENGINEERING COMPANY (1906), LIMITED, SOUTHPORT.



are white metal lined, are also characteristic of this reliable machine. Lubrication is maintained by means of a pressure-feed system, for which purpose a gear-driven valveless pump is situated in the bottom half of the crank-case. The effective pressure of the oil may be varied by the adjustment of an external valve stem nut, and a gauge is provided to show the amount of oil present in the crank-case. The gear gives four speeds and reverse, and the standard speed reductions available are such that the full load may be driven up any average hill on top speed, while the use of the third speed will usually meet exceptional conditions. The gear wheels are made of alloy steel and case-hardened to resist wear. Springing has received careful consideration, and the materials used, for the semi-elliptic type used at the front and three-quarter elliptic ones at the rear, have made the continuance of comfortable travel possible in spite of the heavy usage to which a taxicab is subjected.

The British aim in the design of commercial motors has generally been towards the production of a simple and straightforward arrangement of the components and the elimination of all avoidable complication. This outlook is well illustrated in the design of the 2-ton Vulcan chassis, which is exhibited on the stand of the makers, the Vulcan Motor and General Engineering Company, Limited, of Crossens, Southport, fitted with bodies for representative services such as timber wagon, tipping wagon, omnibus and char-a-banc. The illustrations, Figs. 15 to 25, on Plate XL, and Figs. 26 to 29, on the present page, show the design not only of the chassis but also of its components.

The chassis frame, Figs. 15 and 16, is made up of straight channel sections with many cross ties, and is carried at both ends on semi-elliptic springs. The steering system, Figs. 17 to 20, is of the worm wheel type of which the base chamber is mounted between the engine and a side frame. The control levers, Fig. 18, are mounted at the top of two concentric tubes by means of which their movement is conveyed to levers below the box and through them to the ignition system and the throttle of the carburettor. The shaft for the worm wheel of the steering system is flanged to obtain ample support for the worm, to which it is connected by six rivets. From this shaft motion is taken to the steering arm, and so to the swivel brackets for the hubs of the front wheels, Fig. 21. Here cylindrical brass bushes are in use, but a ball race is installed to take the thrust on the front axle, which is a drop-steel forging of I-section.

At the forward end of the chassis an engine of 22-4 h.p. on the R.A.C. rating is mounted. This power unit, which has four cylinders, cast monobloc, of which the dimensions are 95-mm. bore and 130-mm. stroke, is shown in Fig. 22, from the examination of which the simplicity of the design is at once apparent. The crankshaft has been drilled throughout and the external openings closed by small bolt-held covers except at the bearings. The oil reaches the big-ends from the bearings. In this way effective lubrication has been assured for the rotating system, while the pistons receive their lubricant by the splash method. It will be observed from the left-hand side of Fig. 22 that an oil scraper ring is fitted to the foot of the skirt of the piston, in addition to the three at the top which serve the purpose of preserving gastightness. A gear-driven camshaft, with cams cut out of the solid, is used to actuate the side-by-side valves by means of adjustable tappets with rollers at their ends. A simple cover, on the side of the engine, is all that it is necessary to remove to get at the tappets for adjustment. Above each valve there is a plug, and these accommodate release or priming cocks and sparking plugs. A drive is taken from the timing gear for the water pump and magneto which are installed at one side of the crank-case. They are in line, and the drive is taken from one to the other through flexible couplings. A drive is also taken from the crankshaft by belt to work the fan, and adjustment is possible at the point of suspension of its bearing on the main casting. Beside this there is another belt drive for the dynamo, and it also may be tightened up. The dynamo is supported on a swinging bracket which can be set and fixed in any position to suit the conditions. To keep the induction pipe warm it is carried through the top of the water jacket at the middle section, and the carburettor is consequently located on the other side of the engine from the valves.

The transmission is effected through a Ferodo lined clutch, fitted with adjustable springs and a flexible disc type of universal joint to the gear-box from which it is taken to the live axle, by a propeller shaft fitted with a compound type of universal joint of the cross-pin pattern. The rear axle is driven by a worm and wheel. Figs. 23 and 24 give a clear indication of the arrangement of this part of the system. The axle is of the full floating type, and its outer case is composed of a split centre case and tubes made of cast steel. Into these the substantial axle tubes are pressed, and carry the wheels on floating bearings. In this type of construction the differential shafts, which transmit the drive to the wheels, may be easily withdrawn. On each rear wheel there is an internal expanding brake operated from a hand lever. In these the pads are semi-circular. They are pinned together at the one end and brought into action by a cam between the other ends. Springs connecting projections on the inside faces of the pads serve to pull the brakes out of action the moment that the cams are turned back into their inoperative position. Two different sections of the brake are shown on the wheels in Fig. 23, while Fig. 25 shows the general arrangement of the system. Another brake, but of the external type, is provided on the transmission system beside the gear-box, from which support is obtained. This with the speed reduction system is shown in Figs. 26 to 29, on this page. The motion for this brake is obtained from a pedal and is transmitted through a lever system to pull the brake blocks together. As will be seen in Fig. 28, a simple means of brake adjustment is available. Four speeds are provided by the gears, of which the standard ratios are 7¾, 12, 20 and 31 to 1, while the reverse gives a reduction of 41½ to 1. From Figs. 26 and 27 the locations of the toggle, sliding and countershafts are apparent and, it will be noticed, that they are all mounted on ball bearings. The whole arrangement is such that either a central or a right-hand gate change may be fitted.

COMMERCIAL MOTOR LORRY CHASSIS AT OLYMPIA.

CONSTRUCTED BY THE ASSOCIATED EQUIPMENT COMPANY, LIMITED, ENGINEERS, WALTHAMSTOW.

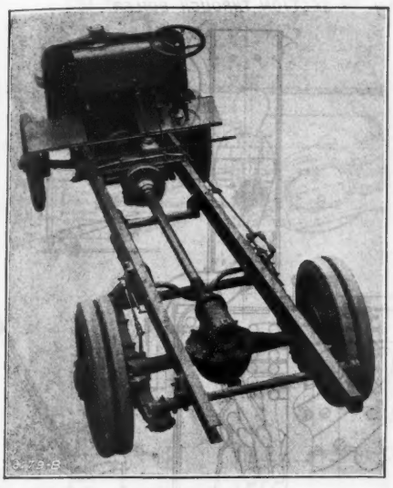


FIG. 30.

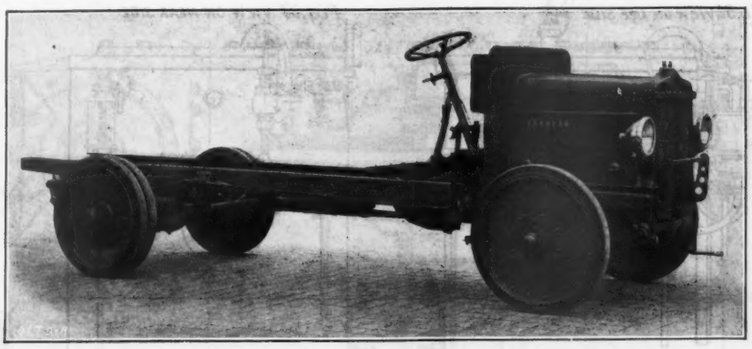


FIG. 31.

Messrs. Leyland Motors, Limited, of Leyland, Lancs., are showing numerous vehicles for the transport of passengers and goods, and in addition a motor fire engine of the firm's characteristic type, equipped with a 500-gallon Rees Roturbo multi-stage pump. Prominent on the stand are a pair of the new Leyland 30-cwt. chassis, equipped one with a brewers' dray body and the other with a 20-seat 'bus body. The new chassis is another example of the success of British firms in producing a transport vehicle of a much lighter type than the 3-ton or 4-ton lorries which are so familiar. The 30-cwt. chassis is made with three standard lengths of wheel-base, ranging from 10 ft. 6 in. to 13 ft. 6 in. Its engine is of the monobloc type with four cylinders, 3½ in. bore by 5½ in. stroke, and the cylinders are cast solid with the upper part of the crank case. The cylinder heads, which are hemispherical in shape, are all cast in one piece, so as to form a detachable block carrying the overhead camshaft. The valves are of the tulip pattern, and are opened by rocker arms actuated by the camshaft. Each pair of valves is closed by a laminated steel spring. The main bearings are lubricated by oil under pressure, the oil finding its way to the crank pins and gudgeon pins through holes drilled through the crankshaft and connecting rod respectively. The standard chassis is fitted with 36 in. by 6 in. pneumatic tyres and has a speed of 20 miles per hour on top gear, with the engine running at its rated speed of 1,050 r.p.m. The engine is capable however of driving the vehicle at a maximum speed of 35 m.p.h. on the level, or of climbing a gradient of one in five with full load on low gear.

Another 30-cwt. vehicle is that shown by Messrs. Karrier Motors, Limited, of Huddersfield. The four cylinders in this case are cast in pairs with all valves on the near side of the engine. The cylinders are 4 in. bore by 5 in. stroke. A manifold casting bolted to the top of the cylinders takes away the cooling water from all four, and when removed allows very easy access to the cylinder jackets for cleaning. The water passages are so proportioned that cooling may be adequately effected by natural circulation, although usually a pump keeps the water circulating through the radiator. Special care has been taken to ensure thorough draining of all parts of the water-system so as to obviate any danger in cold weather. The wheelbase of the chassis is 11 ft. and the track 4 ft. 8 in. The back axle is driven by an over-running worm, and the thrust of the drive is taken by the rear springs. Pneumatic tyres are fitted, those at the front being 36 in. by 6 in., and the rear tyres 38 in. by 7 in. The vehicle is constructed to the new War Office subsidy specification. Messrs. Karrier Motors, Limited, are also showing a 20-cwt. chassis, with an engine rated at 18·2 h.p., mounted with its gear-box as a single unit. Four forward speeds and a reverse are provided, and the final drive is by means of an over-running worm.

The Associated Equipment Company, Limited, of Walthamstow, London, have introduced an entirely new model, which is available for inspection at Olympia. This machine was designed for use in carrying either passengers or goods and will deal with a net load of 2 tons or a gross load, including the body, of 2 tons 15 cwt. In this production the aim of the designers was to keep down the price and to ensure low cost of running. The usual standards of material and accuracy of workmanship common in the heavier machines manufactured by the A.E.C. people have been maintained in this, but the cost of production has been reduced by simplification of design and by reducing the number and the complexity of the component parts. Two views of the chassis are shown in Figs. 30 and 31.

The frame consists of two parallel side members of channel section joined by six cross members, five of which are tubular while the other is a steel pressing. On this frame the engine is supported at three points, the two at the back being arms extending from the crank-case, while a single support carried in a trunnion bracket on the front cross-member, consists of a tapered tubular extension of the steel cover of the distribution casing. The cylinders have separate liners with flanged tops which are machined to be a push fit in the main casting of the engine. The valves are operated through adjustable tappets, with mushroom ends. A separate casting supports the guides for the tappet rods and is held in place by studs which also serve to hold the cover plates in position. From this chamber ports communicate with the interior of the crank-case, and thus the valve stems are continuously lubricated by the mist of oil which is thrown up. Oil is drawn from the sump through a filter to the pump, which is attached to the crank-case, and is therefore not disturbed when the sump is removed. The pump delivery is taken to troughs under the big ends and by a pipe to the distribution gears, but the aluminium pistons are lubricated by splash. Dynamo ignition is used, the supply being obtained from the lighting generator and passed through an induction coil. A combined contact breaker and distributor for the system is mounted on the rear end of the cylinder head. The transmission is effected through a cone clutch, and although fabric discs are used the weight of the shaft is not taken by them, for the spiders are supported in spherical bearings. There is provision made for auxiliary drives from the gear-box for such purposes as tipping, operating lifting tackle or turning a cable drum. The propeller shaft is tubular with solid ends and Spicer joints, and an overhead worm gearing gives the final drive. The brakes on the rear wheels are interchangeable with the one located on the transmission system, and are of the internal expanding type.

Halley's Industrial Motors, Limited, of Yoker, Glasgow, show examples of the uses of three different sizes of chassis. In all of these the good qualities of design and construction are apparent which were seen in a vehicle for a most exceptional service which we lately described in ENGINEERING (see page 140 *ante*). That machine was required to work under the very troublesome conditions due to the rarified atmosphere found at high altitudes. Since the article was written the machine has had some months of test, quite sufficient to indicate its capabilities. It may be said that in every way the machine has performed its duties satisfactorily and has had some service at 17,000 feet above sea level, which is, of course, much greater than the value of 15,800 ft. which was mentioned on the article and was the subject of the guarantee. The largest chassis on the stand has a six cylinder engine of 75-95 h.p. and is fitted with a fire engine body. It is representative of the modern high duty motor fire engine and has a turbine pump of 500-600 gallons capacity. A 35 h.p. chassis has a tank fitted to it for use in gulley or cesspit emptying or in road sprinkling. For raising water from a low level a vacuum pump is bolted to the gear box through which it receives its drive. Another feature of the installation is that the discharge from the tank may be accelerated by the creation of a pressure above the liquid by the operation of a pump. The 25-h.p. chassis is exhibited in use for two forms of single-decked omnibus and also with a refuse-tipping wagon with a capacity of 2½ tons.

An Atkinson-Uniflow 6-ton steam wagon is exhibited by the makers, Messrs. Atkinson and Co., of Preston. This model has an engine of 35 h.p. with two cylinders of 7-in. bore and 10-in. stroke. This application of the uniflow engine system to a steam vehicle was dealt with in our columns in February of last year (see vol. cxiii, page 162) when we described a five-ton model fitted with a tipping wagon made by the same firm. In this new model provision has been made for gear changing when the vehicle is run in hilly country. In former designs suitable sprockets for the final drive were chosen on the basis of the worst gradient to be encountered. The provision of a two-speed epicyclic gear makes possible the working under good conditions on the level as well as the use of a suitable speed reduction for work on inclines. With a drive through gearing on a wagon propelled by a steam engine, which has itself a large margin of flexibility of running, no difficulty should be experienced in negotiating the steepest roads.

The Sentinel Wagon Works (1920), Limited, of Shrewsbury, are showing several examples of the well-known "Super-Sentinel" steam wagons, of which the largest is a six-wheeler with a platform 23 ft. 3 in. long by 6 ft. 11½ in. wide, capable of

BOILER AND PUMP OF "SUPER-SENTINEL" STEAM WAGON AT OLYMPIA.

CONSTRUCTED BY THE SENTINEL STEAM WAGON COMPANY (1920), LIMITED, ENGINEERS, SHREWSBURY.

Fig. 32. VIEW ON OFF SIDE.

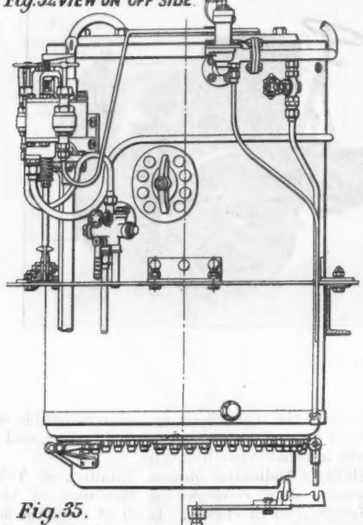


Fig. 33. VIEW ON NEAR SIDE.

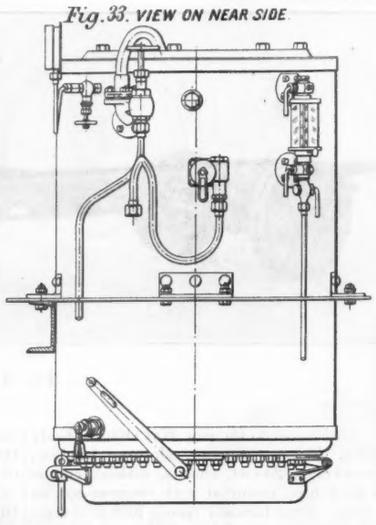


Fig. 34. SECTION THROUGH BOILER.

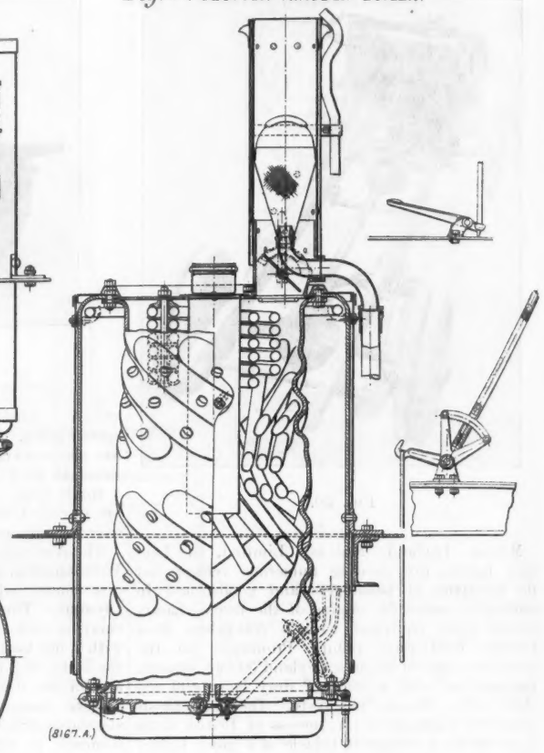


Fig. 35. HALF PLAN OF BOILER & FIRECRATE.

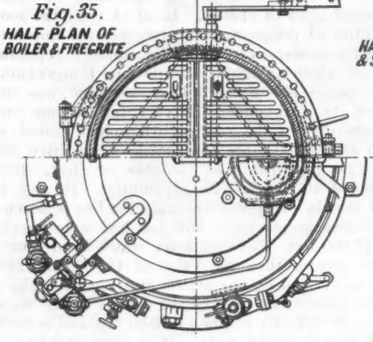


Fig. 36. HALF PLAN OF BOILER & SECTION ACROSS TUBES.

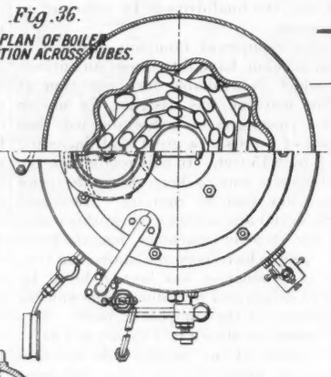


Fig. 38.

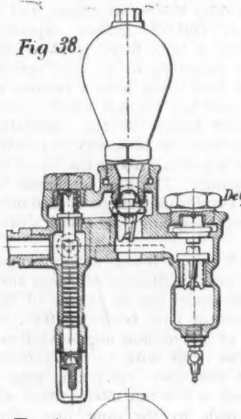


Fig. 37.

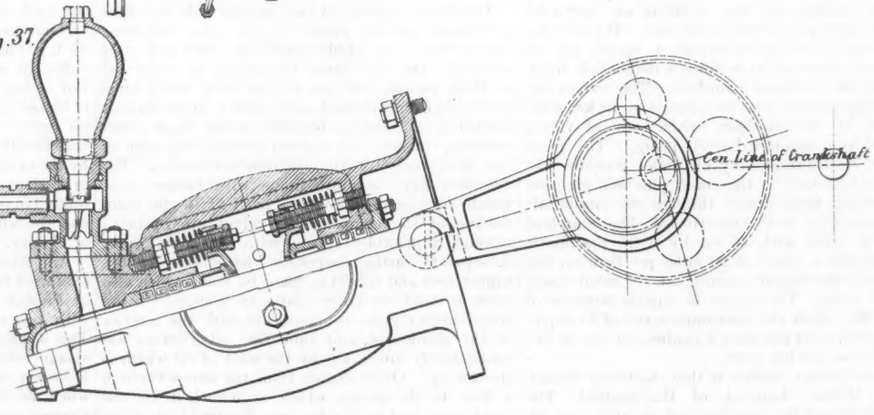


Fig. 40.

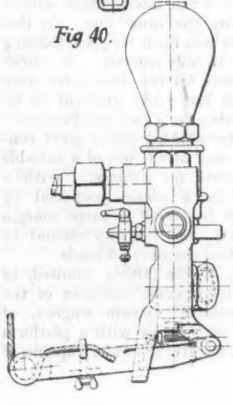
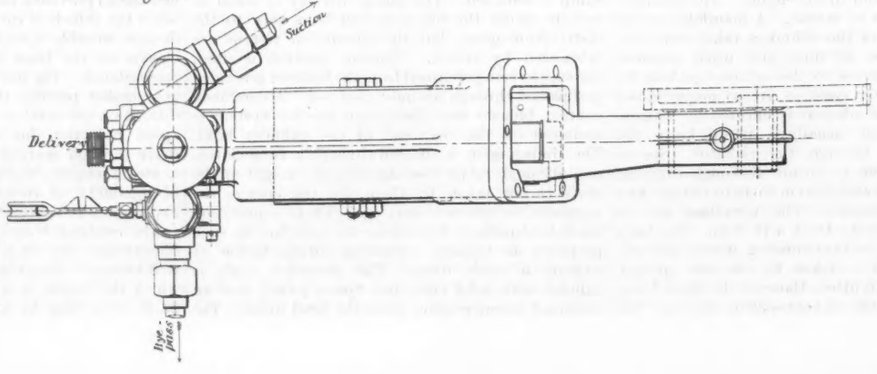


Fig. 39.



ENGINE OF "SUPER-SENTINEL" STEAM WAGON AT OLYMPIA.

CONSTRUCTED BY THE SENTINEL STEAM WAGON COMPANY (1920), LIMITED, ENGINEERS, SHREWSBURY.

Fig. 41.

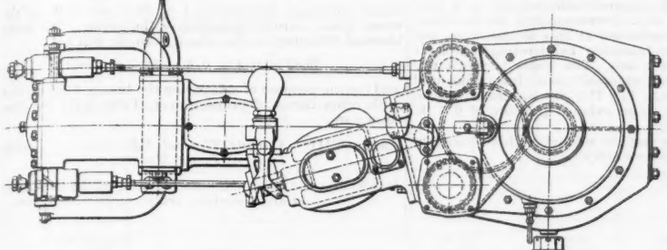
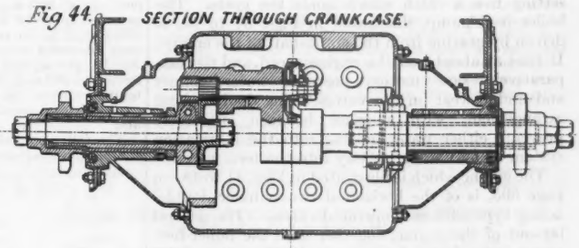


Fig. 44. SECTION THROUGH CRANKCASE.



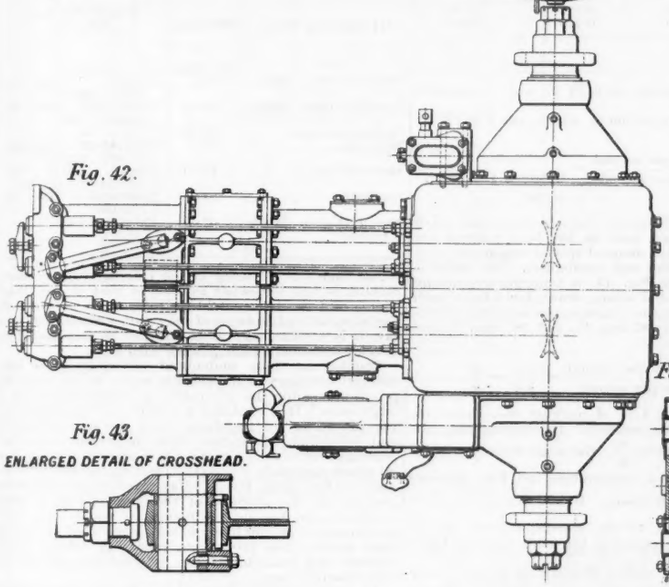


Fig. 45.

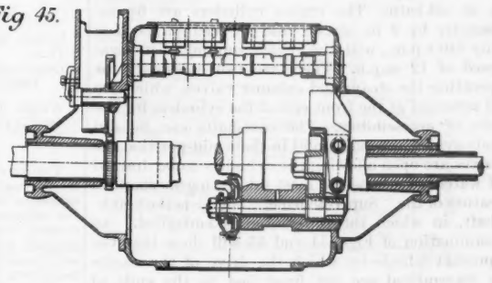


Fig. 42.

Fig. 43. ENLARGED DETAIL OF CROSSHEAD.

Fig. 46. SECTION THROUGH CRANKCASE LOOKING TOWARDS CAMSHAFT.

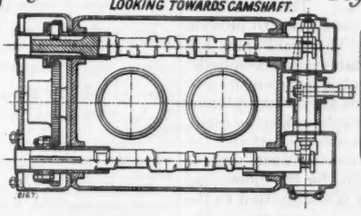


Fig. 47. SECTION THROUGH CONTROL BOX.

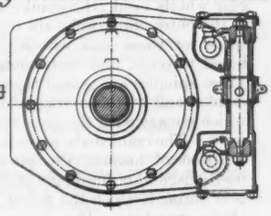
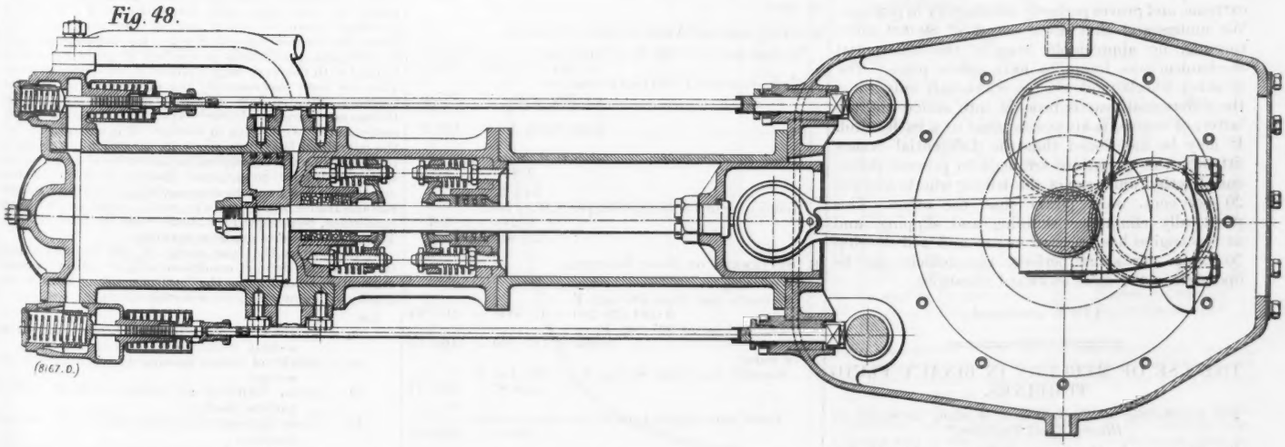


Fig. 48.



carrying a normal load of 10 tons at the legal limit of 12 m.p.h. A 5-ton wagon with a three-way tipping body is also on the stand together with a rather larger vehicle arranged for tipping backwards only. The Sentinel wagon, in its various forms is too familiar an object of the roads for it to be necessary for us to illustrate its general appearance, but in Figs. 32 to 48, on the present and opposite pages, we reproduce drawings of the boiler and engine, which well show the distinctive features of the machinery. The boiler, illustrated in Figs. 32 to 36, is of the vertical type, working at a pressure of 230 lb. per square inch, and is situated right in the front of the vehicle. Probably no class of boilers in the world are operated under more adverse conditions than those for road vehicles, which have to use any kind of water available and are given the minimum of skilled attention.

The cylindrical fire-box is fitted with a large number of steeply-inclined water tubes, the ends of which are expanded into holes in recesses pressed around the circumference. The steepness of the tubes tends to keep them clean, and also facilitates the water circulation. As will be seen from Figs. 34 and 36, the tubes are so arranged as to occupy the whole of the annular space to be traversed by the hot gases between the wall of the fire-box and the central stoking shoot. Above the tubes is a superheating coil through which the steam passes on its way to the engine. The whole design of the boiler is well worthy of attention. The short straight tubes are most unlikely to give trouble of any kind, and the entire construction is simple and solid. The tube ends are in the water space, so that they cannot become burnt. A steam jet is fitted, by means of which the fire-surfaces of the tubes may be freed from soot, and when a thorough cleaning or inspection of the boiler is desired, the whole of the fire-box, with its tubes, can be removed from the boiler while the latter is still in position, by undoing a pair of bolted joints. No steam pipes or other connections have to be disconnected for this operation. The bolted joints have machined faces and are well away from the action of the fire.

The fuel generally used is gas coke, on account of

its cheapness, but hard coal is equally suitable, and results in a considerable saving of the weight of fuel required per mile. Charcoal may also be used. Firing is easy, as the fuel is fed direct through the shoot on to the fire, and the tilting fire-grate simplifies the work of disposing of clinker should any be formed. The whole fire may be dropped by setting free a catch which holds the grate. The boiler feed pump, illustrated in Figs. 37 to 40, is driven by gearing from the crankshaft of the engine. It runs at about half the engine speed, and its comparatively slow motion prevents water-hammer and undue wear on the valves. The double gland arrangement, with a space between effectively prevents either water getting into the lubrication system or oil finding its way into the feed water.

The engine which is illustrated in Figs. 41 to 48, on page 695, is of the horizontal two-cylinder double-acting type with cam-operated valves. The general lay-out of the engine, together with the boiler-feed pump just referred to, is shown in Figs. 41 and 42. The working parts are effectively enclosed and work in an oil-bath. The engine cylinders are $6\frac{3}{4}$ in. diameter by 9 in. stroke, and the engine speed is only 240 r.p.m., with the vehicle running at its legal speed of 12 m.p.h. There are two camshafts for operating the steam and exhaust valves, which are all arranged at the front end of the cylinders for the sake of accessibility. The camshafts can be slid endways for reversing, and in their mid-position the valves are open allowing the cylinders to be drained of water. Perhaps the most interesting mechanical feature of the "Super-Sentinel" engine is the crankshaft, in which the differential is embodied. An examination of Figs. 44 and 45 will show that the sprocket wheels by which the drive of the engine is transmitted are not fixed fast to the ends of the crankshaft, but are mounted on spindles running through the ends of the shaft, and terminating in gear wheels inside the crank-case. The inner sides of the outer crank-webs are recessed out to provide space for these gear wheels. The crank pins are bored through, and each contains a short spindle. These spindles are geared together between the two cranks, and at their outer ends they carry pinions which engage with the gear wheels inside the crank webs. The crankshaft, as such, merely performs the function of keeping the pistons in their relative positions, and of forming a casing for the differential gear through which the power is transmitted to the chain sprockets. The design is ingenious in the extreme, and proves perfectly satisfactory in practice. We understand that after a test of 80,000 miles running, no appreciable wear of the differential mechanism was found to have taken place. The sprocket wheels move on the crankshaft only when the differential gear is brought into action and the latter, of course, is always running in a bath of oil. It may be mentioned that the differential brakes fitted to the wagon are arranged to prevent differential action until one of the driving wheels absorbs 20 per cent. more power than the other. This practically eliminates skidding and slipping, and as the engine has no dead centre and will develop 70 b.h.p. for short periods, the vehicle can be operated in the most awkward situations.

(*To be continued.*)

THE USE OF MERCURY IN BINARY FLUID TURBINES.

*The Possibilities of Mercury as a Working Substance for Binary Fluid Turbines.**

By William J. Kearton, M.Eng., of the Walker Engineering Laboratories, University of Liverpool.

(*Concluded from page 667.*)

13. *Theoretical Thermal Efficiency of the Binary Fluid Turbine with Steam and Mercury Vapour as the Working Substances.*—The theoretical thermal efficiency may be easily obtained by reference to the Mollier Chart and Tables of Properties. This has been done for four initial pressures of dry saturated mercury vapour, a final pressure of 0·5 lb. per square inch abs. in the steam turbine exhaust branch, a hot-well temperature of 80 deg. F., and for a number of steam pressures varying from 64 lb. per square inch abs. to 600 lb. abs. For the purpose of simplifying the calculations, the steam is assumed to be initially dry and saturated, and, moreover, the final temperature of the condensing mercury vapour is taken to be the same as the nitial steam temperature. Actually, the steam temperature will be somewhat lower, owing to the "drop" necessary for the transmission of heat from the mercury to the steam.

In order to illustrate the quantities of heat to be dealt with, an example of one of the above-mentioned calculations will be set out as follows:—

Conditions.—Initially dry saturated mercury vapour at a pressure of 100 lb. per square inch abs. and a temperature of 907 deg. F, expands adiabatically to a final pressure of 0·29 lb. abs. (corresponding temperature, 382 deg. F.). It is condensed at this temperature, the heat liberated on condensation evaporating water at 200 lb. per square inch abs. The water is previously heated to 382 deg. F. (by external means) from a hot-well temperature of 80 deg. F. The dry saturated steam expands adiabatically to an exhaust pressure of 0·5 lb. abs.

The following table may be set out with reference to the Mollier diagram for mercury:—

p.	x.	ϕ.	I.
100·0	1·000	0·1257	154·45
0·29	0·701	0·1257	102·49
—	—	—	51·96

Latent heat of mercury at 0·29 lb. abs. = 129·582 B.Th.U.

Latent heat of steam at 200 lb. abs. = 843·2 B.Th.U.

∴ Ratio:

$$\frac{\text{Weight of mercury per second}}{\text{Weight of steam per second}} = \frac{843 \cdot 2}{0 \cdot 701 \times 129 \cdot 582} = 9 \cdot 284.$$

This ratio, is, unfortunately, high, thanks to the small latent heat of mercury, and, as has been pointed out earlier in the paper, will demand special consideration in the design of the boiler and economiser. The point is further illustrated by Fig. 13, a temperature-entropy diagram for mercury and steam, drawn for 1 lb. of each substance, the temperature limits in the respective cycles being 907 deg. F and 382 deg. F., and 382 deg. F. and 80 deg. F. The ratio—

$$\frac{\text{Weight of mercury per second}}{\text{Weight of steam per second}} = \frac{f\,g}{a\,d} = \frac{w_1}{w_2}.$$

The work areas per 1 lb. of mercury and steam are $a\,b\,c\,d$ and $e\,f\,g\,h$ respectively. By multiplying the entropy ϕ_m by the ratio $\frac{w_1}{w_2}$, the work done per lb. of mercury ($\phi_m \cdot \delta T$ for a temperature fall δT), becomes $\frac{w_1}{w_2} \cdot \phi_m \cdot \delta T$ per lb. of steam. Hence the area $f\,k\,l\,g$ is the actual work area for the mercury-vapour turbine when the area $e\,f\,g\,h$ represents the work done per lb. of steam.

By reference to the Mollier diagram for steam, it may be shown that the heat drop is 367 B.Th.U. Hence, referring all quantities of heat to 1 lb. of steam per second, we have:—

A. Statement of Work Done.

	B.Th.U.
Work done per 9·284 lb. of mercury = 9·284 × 51·96 =	482·3
Work done per 1·000 lb. of steam = 1·000 × 367 =	367·0
Total work done =	849·3

Hence steam consumption per S.H.P. hour = $\frac{2546}{849 \cdot 3} = 2 \cdot 997$ lb.

Hence mercury consumption per S.H.P. hour = 9·284 × 2·997 = 27·825 lb.

B. Statement of Heat Supplied.

To mercury—	
Sensible heat from 382 deg. F. = 9·284 (29·206 − 11·545) =	163·95
Latent heat at 907 deg. F. = 9·284 × 125·249 =	1162·75
To water—	
Sensible heat from 80 deg. F. to 382 deg. F. = 1 × 306·87 =	306·87
Total heat supplied per lb. of steam in the circuit =	1633·57

Thermal efficiency = $\frac{849 \cdot 3 \times 100}{1633 \cdot 57} = 51 \cdot 99$ per cent.

The results of the aforementioned calculations are illustrated graphically in Fig. 14, all curves being drawn on a base of steam pressures. If the ratio $\frac{L}{C}$ were the same for mercury as for steam at the same temperatures, then the thermal efficiency of the ideal binary fluid turbine for given temperature limits would be constant. At lower steam pressures, however, owing to the higher value of the ratio $\frac{L}{C}$ for mercury and the increased heat drop in the mercury vapour turbine, the thermal efficiency is not constant, but reaches a higher value.

As is to be expected, the thermal efficiency is higher, the higher the initial temperature of the mercury vapour. With a temperature of 1,000 deg. F. and a steam pressure of 100 lb. per square inch, the theoretical efficiency is no less than 55 per cent. If it be assumed that an initial temperature of 812 deg. F. is practically possible, the corresponding figure is 50·5 per cent. Assuming, for the purpose of comparison with the steam plant, a boiler efficiency of 80 per cent., a turbine efficiency of 80 per cent., and a generator efficiency of 95 per cent., we have an absolute thermal efficiency of

$$50 \cdot 5 \times 0 \cdot 8 \times 0 \cdot 8 \times 0 \cdot 95 = 30 \cdot 7 \text{ per cent.},$$

which shows an improvement of 32·3 per cent. on the steam plant considered earlier in the paper. The brake thermal efficiency in the above example will be

$$50 \cdot 5 \times 0 \cdot 8 \times 0 \cdot 8 = 32 \cdot 3 \text{ per cent.},$$

and for the purpose of comparing the binary fluid turbine with other forms of prime mover, Table VIII has been drawn up.

Table VIII.—*Absolute Thermal Efficiencies of Various Types of Prime Movers.*

In all cases the efficiencies are based upon the heat in the fuel, and are, therefore, truly comparable values.

Type of Prime Mover.	Efficiency.	Source of Data or Authority.
	per cent.	
Four-cycle Diesel engine	34·2	Chalkley, "Diesel Engine," page 152.
Two-cycle Diesel engine	32–33	Trans. Inst. Marine Engineers, 1922.
Suction-gas engine ..	19–22	—
Still engine	37·7	Engineering, September 2, 1921, page 344.
Steam turbine	19·54*	Trans. A.S.M.E., 1916, vol. xxxviii, page 667.
Gas-turbine	24·7	Holzwarth, "The Gas Turbine."
Mercury-Vapour Steam turbine	32·3	Calculated value.

Although the efficiency of the mercury-vapour steam turbine is still somewhat inferior to that of the Diesel engine and the binary fluid Still engine, it possesses all the important advantages of the steam turbine, that is to say, it is mechanically ideal and can be constructed to develop relatively high powers with ease.

Coupled to these undoubted advantages, its high thermal efficiency will probably make it the foremost prime mover for the generation of electric power on a large scale. It is doubtful if it will ever be adopted for the propulsion of merchant ships, because simplicity and reliability are factors more important than fuel consumption in such a case. On trade routes where fuel oil is comparatively cheap the Diesel engine will probably hold the first place, but on other routes where coal is the cheaper fuel the adoption of the mercury-vapour steam turbine is not beyond the bounds of possibility. Such developments are not likely to take place until the binary fluid turbine has proved its reliability ashore, where failures and breakdowns can be tolerated during the experimental stage.

14. *Choice of Steam Pressure in a Binary Fluid Turbine Plant.*—In recent years the efficient generation of electric power by very large units has introduced a number of problems amongst which one of the most important (from the designer's point of view) has been the provision of sufficient nozzle area in the last stage of the turbine to deal with the very large volume of low-pressure steam. This has been overcome by the provision of double-flow turbines, divided-flow turbines, and, latterly, by the Baumann "multi-exhaust" system. Referring to the statement of work done in Section 13, it will be seen that the combined heat drop per 1 lb. of steam per second is roughly twice the corresponding figure for a steam turbine under ordinary conditions. Hence, if no difficulties arise in the design of the mercury vapour turbine, a steam turbine frame of a given size could, under similar steam conditions, be designed for about twice the normal power. This is a feature of great importance.

It is obvious that the design of the mercury-vapour turbine under defined conditions will, or will not, present difficulties according as the final pressure of the mercury vapour is below or above a certain figure.

Let

w_1 = weight of mercury passing through turbine per second.
w_2 = weight of steam passing through turbine per second.
D_1 = mean diameter at exhaust end of mercury turbine (inches).
D_2 = mean diameter at exhaust end of steam turbine (inches).
m_1 = ratio of nozzle height to mean diameter in mercury turbine.
m_2 = ratio of nozzle height to mean diameter in steam turbine.
v_1 = final specific volume of mercury in cubic feet per lb.
v_2 = final specific volume of steam in cubic feet per lb.
N = revolutions per minute of turbines.
V_1 = exit velocity of mercury from last stage nozzles.
V_2 = exit velocity of steam from last stage nozzles.
ρ_1 = blade speed ratio for mercury turbine.
ρ_2 = blade speed ratio for steam turbine.

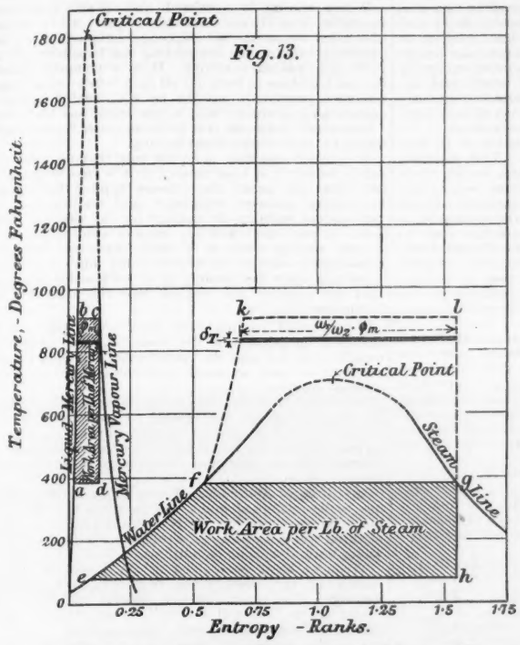
* Paper read before the Institution of Mechanical Engineers, on Friday, November 16, 1923.

* A boiler efficiency of 80 per cent. has been assumed here. The steam conditions in this case are moderate, being:—Initial pressure, 209 lb. per square inch gauge; total temp., 500 deg. F., vacuum 28·86 in. Hg. (30 in. bar.).

Then the area through the last stage nozzles of the mercury vapour turbine $= \frac{144 \cdot w_1 v_1}{V_1}$ square inches, and

since $$V_1 = \frac{u_1}{\rho_1} = \frac{\pi D_1 \cdot N}{720 \rho_1} = \frac{D_1 \cdot N}{229 \rho_1}$$

$$\text{Area} = \frac{144 \, w_1 \cdot v_1}{D_1 \cdot N} \times 229 \, \rho_1.$$



Temperature-Entropy Diagrams for Mercury Vapour and Steam plotted to the same scale.

Note:-The dotted portions of the Diagrams are conjectural, particularly in the case of Mercury.

(8157.N.)

But the area through the nozzles $= \pi D_1 l_1 c \cdot \sin a_1$ square inches—

where l_1 = radial height of nozzles.
a_1 = outlet angle of nozzles.
c = "thickness coefficient" for vanes.

That is, area $= \pi m_1 \cdot D_1^2 \cdot c \cdot \sin a_1$.

$$\therefore \pi m_1 \cdot D_1^2 \cdot c \cdot \sin a_1 = \frac{144 \, w_1 v_1}{D_1 \cdot N} \times 229 \, \rho_1.$$

From which

$$D_1^3 = (w_1 v_1) \times \frac{144 \times 229 \, \rho_1}{\pi \cdot N \cdot m_1 \cdot c \cdot \sin a_1}$$

Similarly, for a steam turbine,

$$D_2^3 = (w_2 v_2) \times \frac{144 \times 229 \, \rho_2}{\pi \cdot N \cdot m_2 \cdot c \cdot \sin a_2}$$

Assuming that $\rho_1 = \rho_2$, $m_1 = m_2$, that c is constant, and that $a_1 = a_2$, then

$$\left(\frac{D_1}{D_2}\right)^3 = \frac{w_1 \cdot v_1}{w_2 \cdot v_2}.$$

For any given initial pressure of mercury and any diameter ratio $\frac{D_1}{D_2}$, a value may be assumed for the initial steam pressure. The value of the ratio $\frac{w_1}{w_2}$ may then be calculated exactly. For the assumed steam pressure and an assumed efficiency ratio the final specific volume v_2 of the steam may be calculated. This enables the final specific volume of the mercury vapour, and, in turn, the initial steam pressure to be determined. Thus, by a process of trial and error the steam pressure may be obtained.

On the assumption that the steam is initially dry and saturated, the specific volume at exhaust has been calculated for varying initial pressures and vacua of 27½, 28, 28½ and 29 in., the efficiency of the turbine being taken as 80 per cent. The results are shown graphically in Fig. 15. A similar calculation has been made for mercury for initial pressures of 180, 100, 50 and 20 lb. per square inch and varying back pressures; the results are set down in Fig. 16 against a uniform scale of pressure of dry saturated steam having the temperature corresponding to the back pressure of the mercury. It will be noticed in both cases, but particularly in the case of mercury, that the initial pressure has a very small effect on the final specific volume.

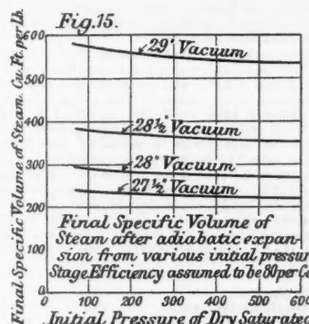


Fig. 15.
29" Vacuum
28½" Vacuum
28" Vacuum
27½" Vacuum
Final Specific Volume of Steam after adiabatic expansion from various initial pressures. Stage Efficiency assumed to be 80 per Cent.
Final Specific Volume of Steam. Cu. Ft. per Lb.
Initial Pressure of Dry Saturated Steam - Lb. per Sq. Inch.

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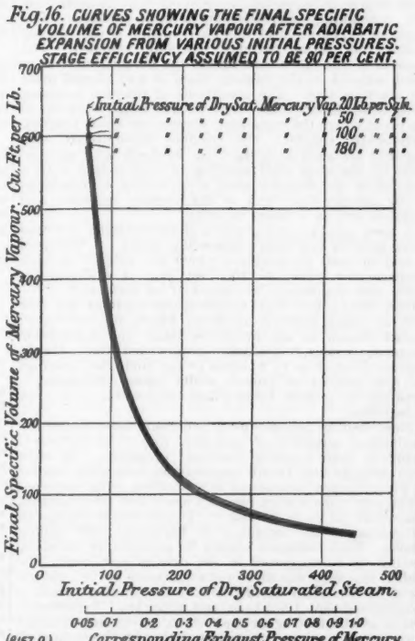


Fig. 16. CURVES SHOWING THE FINAL SPECIFIC VOLUME OF MERCURY VAPOUR AFTER ADIABATIC EXPANSION FROM VARIOUS INITIAL PRESSURES. STAGE EFFICIENCY ASSUMED TO BE 80 PER CENT.
Initial Pressure of Dry Sat. Mercury Vap. 20 Lb. per Sq. In.
50
100
180
Final Specific Volume of Mercury Vapour. Cu. Ft. per Lb.
Initial Pressure of Dry Saturated Steam.
Corresponding Exhaust Pressure of Mercury. Lb. per Sq. Inch.

(8157.Q.)

Hence, for a single-flow mercury-vapour turbine and a single-flow steam turbine we have—

$$v_1 = v_2 \cdot \frac{w_2}{w_1} \cdot \left(\frac{D_1}{D_2}\right)^3.$$

For a double-flow mercury-vapour turbine and a single-flow steam turbine we have—

$$v_1 = 2 \cdot v_2 \cdot \frac{w_2}{w_1} \cdot \left(\frac{D_1}{D_2}\right)^3.$$

A series of calculations have been made for varying vacua in the steam condenser and diameter ratios $\frac{D_1}{D_2}$ equal to unity and 1·1. The results are exhibited in Fig. 17. The values calculated have been further modified by the assumption of a "drop" of 30 deg. F. between the condensing mercury vapour and the steam. These results are illustrated in Fig. 18.

In view of the low heat-drop in the mercury-vapour turbine, it is probable that the best results would be obtained by the use of a single-expansion, double-flow turbine, having as large a diameter as feasible. Amongst other advantages, this scheme possesses the following:—

(*a*) The chest containing the high-temperature poisonous vapour can be made unicellular, thus eliminating the risk of leakage.

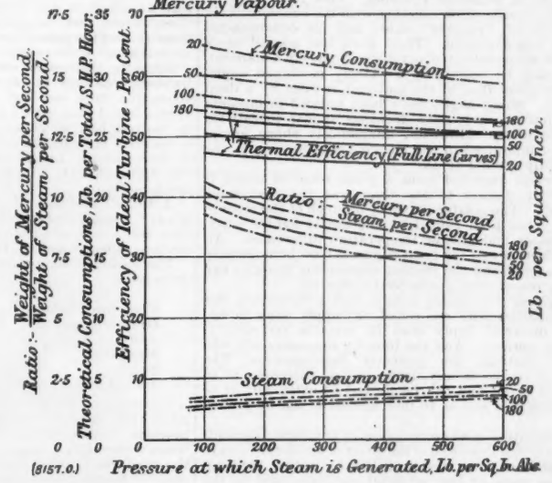
(*b*) The connection between the casing and this chest could be made as thin as possible so as to diminish the loss of heat to the turbine casing by conduction.

(*c*) The external glands would be subjected to a negative pressure of mercury vapour. Thus leakage to the atmosphere would be entirely eliminated, except, perhaps, when starting up. Such glands could be packed by liquid mercury whirling in a casing and set in motion by an impeller on the shaft.

(*d*) A lower steam pressure can be adopted, which simplifies considerably the design of the mercury condenser and of the steam turbine. At the same time the efficiency is improved.*

Fig. 14. THERMAL EFFICIENCY & CONSUMPTION CURVES FOR BINARY-FLUID TURBINE.

Note:-Figures adjoining curves indicate the initial absolute pressure of the dry and saturated Mercury Vapour.


Mercury Consumption
Thermal Efficiency (Full line Curves)
Ratio :- Mercury per Second / Steam per Second.
Steam Consumption
Ratio :- Weight of Mercury per Second / Weight of Steam per Second.
Theoretical Consumptions, Lb. per Total S.H.P. Hour.
Efficiency of Ideal Turbine - Per Cent.
Lb. per Square Inch.
Pressure at which Steam is Generated, Lb. per Sq. In. Abs.

(8157.O.)

DIAGRAMS SHOWING THE INFLUENCE OF THE VACUUM IN THE STEAM CONDENSER ON THE STEAM PRESSURE IN A MERCURY-VAPOUR STEAM-TURBINE PLANT, FOR THE CONDITIONS ASSUMED IN THE PAPER.

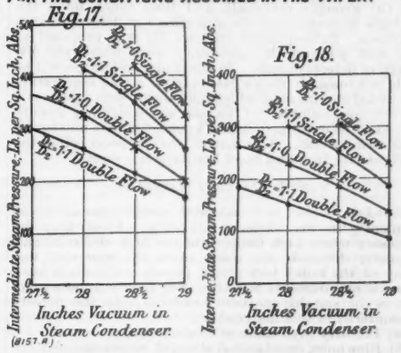


Fig. 17.
Dr 1·0 Single Flow
Dr 1·1 Single Flow
Dr 1·0 Double Flow
Dr 1·1 Double Flow
Intermediate Steam Pressure, Lb. per Sq. Inch, Abs.
Inches Vacuum in Steam Condenser.
Fig. 18.
Intermediate Steam Pressure, Lb. per Sq. Inch, Abs.
Inches Vacuum in Steam Condenser.

(8157.R.)

SPANISH EXPORTS.—The Commercial Secretary at Madrid, in a report to the Department of Overseas Trade, states that Spanish exports of manufactured goods, since the date when the belligerent countries renewed their pre-war activities, have continued to fall, and this is believed to be due, amongst other reasons, to: (1) The high customs duties payable on raw materials; (2) the lack of satisfactory transport from the factories to the ports; and (3) to the fact that Spanish manufacturers do not understand the value of combination in manufacturing competitive lines.

* [The paper was accompanied by three valuable tables giving the properties of mercury vapour calculated by means of the formulæ and by the methods outlined in the paper, but these tables we are, owing to the demands upon our space, unable to reproduce.—ED. E.]

THE EXAMINATION OF DEFECTIVE FERROUS MATERIALS IN AN ENGINEERING WORKS.*

By T. Henry Turner, M.Sc., Assistant Lecturer and Demonstrator, Birmingham University.

In the present paper it is not the writer's intention to deal with "proofing" or routine testing, nowadays applied to all raw materials, but to consider some of the more common abnormalities which appear from time to time in the machine shops of the large modern engineering works. In considering, therefore, the importance of various types of defect, such as one encounters during the machining of ferrous materials in a large engineering works, one must constantly bear in mind the uses to which any particular article will be put when it leaves the manufacturing plant. The endeavour must be made to visualise the part in its normal working position and attempt to estimate the type and magnitude of the stresses to which it will be subjected both under normal and under accidental conditions.

On doing this it is found that surprisingly few steady loads exist, in actual practice; and almost every piece of iron or steel in use appears to be subjected to repeated stressing due to variations in temperature, repeated mechanical loading, alternating stresses, shock or some other form of dynamic stressing. This fact must be taken into consideration together with the comparatively recent work of Professor Coker† and his collaborators on stress concentration. Their work has opened one's eyes to the serious effect of any discontinuity in a material, such as may be caused by a sharply machined angle, a crack or other flaw in the material or even by a deep tool mark. Sharp angles have been noticed in obsolete designs, but all up-to-date drawings appear to call for reasonable fillets. However, dangerously sharp angles may occur unnoticed in the machine shops owing to the use of badly ground tools.

The service expected from a given mass of metal is undoubtedly greater to-day than was the case some years back. The greater efficiency of much of the modern machinery has been gained by the use of lighter parts, higher speeds and greater temperature differences. All of these factors call for greater guaranteed homogeneity in the material and the present engineering practice can only be pursued with guaranteed materials.

An engineer will readily accept such a statement, but the steelmakers who are asked to supply such homogeneous material, reply that in practice no steel is absolutely perfect. And the foundry managers will add that no castings are perfectly homogeneous. The decision in regard to any defect is not, therefore, as to whether it exists and can be proved to exist, but as to how serious it is and as to how serious it can be proved to be.

The estimation of the seriousness of any defect depends upon experience available of the effect of similar defects in similar articles when tested either by actual running, or by the more or less artificial methods used in the laboratory.

In turning now to actual shop examinations we will consider (in Part I) the ferrous raw materials of the engineering shops under two heads: (A) Cast materials, and (B) wrought materials, and then touch upon the methods of overcoming the evil effects of defects in such materials. Subsequently (in Part II) it is proposed to deal with some of the laboratory work which the discovery of defects entails. In particular, reference will be made to a research upon a case of ingot corner segregation in a nickel chrome steel which may throw light upon some "mysterious failures" of the past and which has already proved to be extremely useful knowledge in a number of engineering works. This matter was discussed before the Staffordshire Iron and Steel Institute last year.

Part I.—(A) Cast Materials.

Cast-Iron.—The cast material which appears most frequently in the shops is cast-iron. Steel may be necessary where high temperature or high electrical and magnetic demands are made upon the material, but many of the bulky bed plates, guards and casings have no such requirements to fulfil. For such purposes cast-iron is the suitable material available and the defects encountered in this material are:—

(*a*) Porosity (hydraulic or steam leakage).
(*b*) Blowholes (mechanical strength unsatisfactory).
(*c*) Hard Spots (machinability bad).
(*d*) Warping (dimensions incorrect).

(*a*) Porosity will be shown up when the casting is on water test. This is a simple mechanical test upon the finished casting and should this prove to be porous it is frequently possible to cure the trouble by the addition of salamoniac to the water. Corrosion is encouraged and the casting rusted internally until watertight.

(*b*) Blowholes are practically incurable in a finished casting. When encountered in the shops the metallurgist's first thought should be "prevention is better than cure—are any more of this type of casting on order?" It is frequently possible to save much trouble by quickly calling the attention of the supplier to the fact that blown castings have been received.

The possibility of using a blown casting must of course depend upon the nature of the holes and upon the function of the casting. By knowing how a casting has been made and what service is expected of it one may sometimes be enabled to pass a blown casting as fit for use.

Generally speaking, however, the appearance of blowholes is the signal that it is time to have a consultation with representatives of the foundry. The welding-up of blow-holes in cast-iron is impracticable in almost every case where a good machined finish is required and where thorough annealing is impossible. However, cast-iron is welded by carefully warming the surrounding metal and so preventing the retention of over much carbide in solution by restraining the normal chilling effect of surrounding cold metal.*

(*c*) Hard spots are sometimes encountered in cast-iron and their occurrence causes very considerable delay and expense. Firstly, the machining of a hard casting or a casting containing some hard areas must take longer than does the machining of a softer or a more uniformly soft casting; and secondly additional delay, and expensive loss of time by man and machine tool, is frequently caused by the breakage of tools on account of such hard metal. This tool breakage is in itself an expense.

The question, therefore, frequently arises as to how hard a casting may be to be machinable. This question, so natural to the man in the machine ship, is difficult to answer, since no cast-iron casting is uniform in hardness. The irregularities of design which of necessity call for part of a casting to be thick, whereas the remainder is relatively thin incidentally tend to cause one part to be relatively harder than the other. Machinability depends upon the composition of the metal, the temperature at which it was poured and the rate of cooling. Composition and temperature are controllable in the foundry, but the rate of cooling depends upon the pattern as well as upon the nature of the mould.

Recently the writer arranged for a series of Brinell hardness readings to be taken at standard places on successive large cast-iron castings of a particular type. It was found that with a standard chemical composition in the test bar, which was cast at the time of pouring, a variation of from 150 to 230 Brinell could be measured in the castings. In the cases where the Brinell hardness was approximately 170 no complaints were made in the machine shops.

A Brinell hardness of 200 or upwards of that figure always caused trouble during machining. It would thus seem that cast-iron has a lower limit of machinability—when tested by Brinell—than have most steels.

The chemical composition of the iron castings tested averaged:—

	Per Cent.
Combined carbon	0·60
Graphitic carbon	2·9
Silicon	1·6
Manganese	0·55
Sulphur	0·11
Phosphorus	0·70

In consideration of the above tests it must be borne in mind that, from the point of view of the man in the machine shop, a casting containing hard spots is sometimes worse than a casting which is hard all over, in that the small hard spots in an otherwise soft casting are the cause of frequent tool breakages.

(*d*) Warping frequently occurs in big castings during the first machining operation on a large surface. The apparent explanation of this phenomenon is that during cooling the casting becomes internally stressed. The removal of the outer skin upsets the balance of stresses which existed in the casting when it was placed upon the machine tool. The conditions of internal stressing being thus altered elastic deformation takes place up to the point where the remaining stresses are again resisted.

Generally speaking the troubles encountered with cast-iron are such that they can be dealt with successfully by the shop staff working in conjunction with a member of the foundry staff who, having a knowledge of the pattern shop and of the foundry mixtures and practice, acts in a liason capacity.

A good man in this position is undoubtedly a sound investment in any large engineering works. Cast-iron is seldom used in positions which are subject to high temperatures owing to the fact that it disintegrates under such conditions, as described by Hatfield.†

Cast Steel.—For high temperatures such as are met with in many modern machines which employ superheated steam, or are otherwise liable to considerable temperature rises, it is usual to employ cast steel. Doubt appears to exist as to whether or not such steel castings are also subject to growth under these conditions‡—certainly no growth takes place comparable with that of cast-iron.

Steel castings are also used in certain cases, where the mechanical strength of cast-iron would be sufficient, owing to their superior electrical properties. In such steel castings defects are encountered somewhat similar to those already mentioned in connection with cast-iron. When put under a high pressure water test steel castings sometimes prove to be leaky. This is nearly always an indication of the existence of blowholes and cooling cracks. Such leakiness cannot be successfully cured by rusting up as suggested in the case of cast-iron. The higher temperatures and greater stresses to be encountered by the steel casting makes the smallest crack a dangerous defect if left to extend under the "breathing" action of the casting in use. Such cracks are detected during the machining operations either by the shop staff or by the inspection department. When cracks are discovered the metallurgical staff is notified and the problem then is to estimate how far such cracks extend, how serious they are, what they indicate and whether or not they may be eliminated.

In certain cases no welding is permitted by specification, and then the only available means of countering the crack is to obtain the engineers permission to have a hole drilled at the spot where, after polishing and etching the surface, it is possible to say the crack finishes. The outward side of the hole drilled is then polished and examined and, if no sign of the crack appears there, it is safe to assume that the original crack will not extend under the normal service conditions of the casting.

Where welding is permitted, and reliable welders are available, it is always advisable to have all cracks and blowholes removed by chipping, scraping, filing and polishing, after which the casting can be safely built up with new welded material. It is a common practice in steel foundries to burn out all such defects with oxygen, but such practice is not to be commended in that it cannot be guaranteed that a fine crack has really been "bottomed," and also it is liable to cause further cracks owing to the excessive local heating.

In general one may obey the rule that no crack may safely be left in a steel casting if it is free to extend in any direction under the stresses applied by repeated loading or repeated expansion and contraction. The uninspected welding of castings by the supplier should never be permitted, and any signs of welding noticed on a new casting when it is being machined should be immediately considered as suspicious and chipped out. Time and again the opening up of such welds has shown that the supplier has welded over the neck of a long bottle-like hole.

Where steel castings are used on account of the electrical properties of the material, the stresses are usually very low and the metallurgist has only to judge whether or not external blowholes indicate serious internal cavities.

He should, however, keep an eye open for sharp corners. Electrical engineers are prone to consider steel only from the point of view of magnet iron and in a recent serious breakdown the writer observed the lack of any appreciation of stress concentration by those responsible for the design.

(B) *Wrought Materials.*—A very great variety of work has to be examined under this heading, and great care must be exercised in many cases owing to the high working stresses which the wrought material has to meet under normal working conditions.

Wrought steel is received in the works as rolled or drawn bar, rod, sheet, plate, strip, &c., or as individual forgings. The most common defects encountered are "hair cracks," "sand cracks," "segregation," "ghost marks," "star cracks" and "forging laps." These are due on the one hand to defective ingots and on the other hand to defective hot working of the steel.

Undoubtedly the most common defect met with is the "ghostmark" or "ghostline" a term somewhat loosely used to cover the appearance of a streak of the steel which contains usually a high percentage of phosphorus, a low percentage of carbon and an irregular string of small slag globules. Such markings show up very plainly on a freshly machined surface as a light or dark line or blotch according to the angle at which the light strikes the steel surface.

Such ghostmarks are usually somewhat different in hardness from the neighbouring metal, and thus they cause the tool to jump a little and so produce a slight slope on an otherwise plane surface; this slope reflects the light at a different angle to the remainder of the surface and so betrays the position of the segregation.

This type of segregation appears to corrode more rapidly than does the neighbouring metal and a ghostmark may often be traced on a slightly rusted surface by a quite definite line in the oxide. Actual records of such marks are easily made by sulphur printing and sulphur prints are regularly taken, carefully examined and filed away as permanent records. It should here be mentioned that a sulphur print is able to indicate in certain cases

1. Grain size.
2. Dendritic structure.
3. Nature and position of segregation.

In the examination of large forgings the value of sulphur printing cannot be overestimated.

The taking of sulphur prints is a skilled operation requiring the use of great care and considerable dexterity before really good results can be obtained.

The interpretation of a sulphur print requires considerable experience, and at first one is apt to pay undue notice to white spots and smears which are due to air-bubbles, or to the black spots which are due to badly-cleaned surfaces; a trace of oily oxide on the surface will produce a very black mark. It is not advisable to use a paper with a glossy surface and the writer has had his best prints with a matte paper purchased as of "seconds" quality, although a number of first-class bromide papers have been tried. Wherever possible it is advisable to have the surface from which a sulphur print is to be taken, well polished with a medium emery in order to remove all tool marks. However, very useful prints may be taken from quite roughly machined surfaces, but it should be understood that such prints will not indicate grain size or crystal form.

Where forgings have been worked but little in parts and the original dendritic structure is little altered this may be plainly seen on the sulphur print, being indicated by white lines. In suggesting that grain size is indicated by a good sulphur print the writer refers to the size of the ferrite and pearlite areas and not to the actual crystals, the boundaries of which may be seen in the ferrite or pearlite areas when suitably etched and examined under a magnification of 100 diameters or so.

To deal now with some standard types of forgings in more particular detail we will consider in the first

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* Paper read before the Birmingham Metallurgical Society, March 1, 1923.

† See Coker on "The Effects of Scratches on Materials", Proc.Inst.C.E., 1921, and "Contact Pressures and Stresses," Proc.I.Mech.E., 1921.

* See later "Welding" Part I.

† See Hatfield "Cast-Iron by the Light of Recent Research," Chapter x.

‡ Discussion on Mr. Baumann's paper on "Steam Turbines," Journal I. Elect. Eng., vol. lix, June, 1921, pages 565 to 662.

instance, shafts; second, turbine discs; third, electrical generator rotors; fourth, coil binding rings.

1. Shafts vary from the simple small motor shaft machined out of black bar, or even, in the still smaller sizes from drill rod, to the heavy forgings required for large steam turbines.

The troubles met with in the lowly-stressed simple motor shafts are generally sand cracks and ghostlines. Neither of these defects need be regarded as serious if of small extent and if not situated in some place where they are liable to special stresses. When met with on a journal which has to be polished it will generally be found that the final polish masks them entirely. In such cases the practice is to take a sulphur print record of the defects noticed and also one from either end of the shaft.

If these latter prints indicate that the segregation is evenly distributed the shaft may be considered satisfactory. Care must however be taken with sand cracks and these do not in all cases polish out. If such longitudinal cracks be allowed to remain in a journal they may score the bearing and cause it to run hot.

They will not, however, seriously impair the strength of the shaft. When such cracks are met it is sometimes possible to wash them out by local polishing or remove them by turning the journal below standard size. This latter proceeding is frequently possible on account of the large factor of safety employed on such work, but this policy should only be followed after careful examination of the end sulphur prints.

Larger shafts are generally individual forgings and these are subject to the same general defects and also to the possibility of star cracks in the centre of the shaft. These are due to bad forging practice—too cold a centre or too small a hammer, or forging down with a round section instead of taking the shaft down square as far as possible and finishing off round. Where such star cracks cannot be removed by boring it is necessary to scrap the shaft.

The largest shafts may contain all the above defects and also require to be examined for clinks. The clinking of a large shaft may not be noticeable externally. It is therefore the rule to examine the bore of all such shafts. Such shafts are delivered with a hole 3 in. to 6 in. in diameter drilled along their middle axis. Along this hole a special apparatus consisting of a mirror and electric light, or periscope, is pushed. Then by means of a short focus telescope a thorough internal examination of the shaft is made.

An examination of this kind may take several days, as it is necessary to polish and etch all doubtful places, and this must be done by means of apparatus similar to a chimney sweep's brush and rods. Signs of cracks or sand cracks are most carefully examined, and if the presence of a defect is confirmed the diameter of the bore is increased and a fresh examination is made. This examination is, of course, made primarily on account of the danger of clinks or cracks at right angles to the length of the shaft. However, cracks are from time to time discovered running longitudinally and in the writer's experience these have generally been directly below a marked change in the outside diameter of the shaft. Such cracks when discovered are always removed, and in this connection it is worth mentioning that the strength of a shaft is scarcely impaired by increasing the size of the bore. (Approximately if 30 per cent. of the whole shaft be removed by boring the strength is only reduced by some 3 per cent.)

2. The examination of turbine discs is a routine matter. Every disc has to be passed as metallurgically satisfactory before it is allowed into service. After the disc has been forged and annealed it is rough machined at the maker's works. Test pieces are cut off and tested for tensile and bending properties. If these are satisfactory the disc is delivered to the machine shops for final machining. During this final machining the foreman and the inspector keep an eye on it and notify the metallurgical section should any irregularity be noticed.

Ghostmarks and large slag inclusions are frequently detected in this manner and the disc is in some cases rejected at this stage before further fine work has been done upon it. Should no defect be noticed the disc is shipped fully machined to the disc depot for examination by the metallurgical section. A most careful, inch by inch, examination of the surface is made by a trained man; any doubtful spots are polished with fine emery, etched and examined through a magnifynig glass. A portable microscope is available giving 150 diameters magnification, and a binocular microscope giving 25 diameters is frequently employed in doubtful cases on account of its good illumination and large field.

However, for all normal cases the inspector is able to recognise the type of inclusion, &c., with his unaided eye. Small inclusions of slag are marked and scraped out, a good polish is obtained and the bottom of the depression carefully examined. This is done firstly because it is important to know just how serious the average inclusion in the steel is, and secondly because a smooth surfaced depression is not such a possible source of initiation for a fatigue fracture as would be a slag inclusion. Turbine discs are designed so as to avoid vibration, but in considering the effect of a small inclusion or crack in the metal, it must be borne in mind that should vibration occur it will continue for months on end. Under these conditions any initial defect may be increased in seriousness until, if not discovered in time it would eventually cause the failure of the disc and consequently, of the whole machine.

Thus the greatest care is taken in the examination of all discs. The bore is examined by means of a magnifying mirror—an old plano-concave shaving mirror gave two years' most useful service in all kinds of internal examination in the shops—and sulphur prints are taken from the faces in cases where signs of segregation are visible or reported from the machine shop. All this examination would be of little use without acquaintance with the forging process and with the direction of the metal "flow lines."

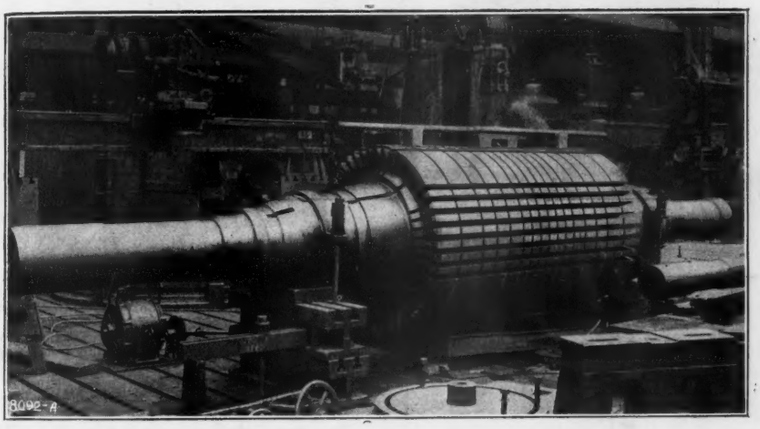

FIG. 1.

The writer has therefore watched the forging of actual discs and repeated the process upon model billets made up of different coloured layers of plasticine. The model discs so forged were sectioned and proved most instructive. Later it was possible to deep etch sections out from actual discs and these compared with the wax models showed very similar flow lines.

In general it may be said that no disc is rejected for ghost marks alone, unless it is known to be unusually highly stressed, and the segregation is very marked or awkwardly placed. Discs are rejected for sponginess blown steel, dirty steel or slag inclusions, but in cases where the inclusions are isolated and small they are all scraped out and the disc is passed for use with a polished depression where the slag spot occurred.

Signs of ingot corner segregation have been discovered on certain discs and this is, of course, a most serious defect. The writer believes that turbine discs can only be satisfactorily worked and heat treated if a hole is punched through the centre before forging is commenced. This is, however, contrary to the practice of many forgemasters. In at least one German works it is the practice to test such discs by rotating and heating to a low temperature. The existence of defects in the disc causes it to be thrown out of truth when warm. The writer has no experience of this test, but he was told of it when visiting a famous turbine factory in Berlin.

3. Field disc rotors for large turbo-generators are very large forgings liable to clinks. The nature of a clink was well shown by a case which recently came to the writer's notice. A forged steel roll fell into two pieces while being turned on the lathe. The fractured surfaces were not oxidised but showed that there had been a cavity nearly 2 ft. in diameter and 2 in. thick shaped like a double convex lens.

Big rotors should always be bored out, and the bore hole examined in the same way as already described for large shafts. Had this always been done one of the recent rotor breakdowns might not have occurred.

Recently it has been the practice to have the centre of the forging trepanned out instead of bored. In this way a solid core is removed, and if this is continuous it may be assumed that no clinking has taken place. Fig. 1 gives an illustration of a core trepanned from a rotor forging and shown resting on wooden blocks above it. In one case examined by the writer the core so removed had excellent tensile properties, a good chemical composition and was not segregated. However, as would be expected, the grain size was some ten times larger than the grain at the outside of the forging.

The writer has seen severe sand crack trouble on the journals, in one case due apparently to a cone of segregation at the bottom of the ingot. Several cases of planes of segregation due to the ingot corners have also been noticed in the largest forgings. This type of segregation is not so serious in this type of forging unless it occurs in such a position as to weaken the wedge retaining teeth. It is obvious that as the rotor is slotted from end to end the metal can be subjected to no hoop stress such as would open a longitudinal plane of segregation.

However, as such planes of weakness might occur dangerously near to the teeth, sulphur prints are taken from the barrel portion of the forging in order that if segregation planes are discovered the slots may be so cut as to remove at any rate the most marked portions.

In one case this ingot corner segregation was so marked as to amount to a crack, and it was found necessary to replace the tooth containing the crack by an inserted tooth.

4. The coil binding rings used on either end of a turbo-rotor when comparatively highly stressed are made from nickel chrome steel, giving from 40–60 tons as may be necessary.

These rings have always been carefully examined and full records of all test results are filed. Recently it has been made a rule that sulphur prints be taken from both the inside and outside of all steel clamp rings and these prints are filed. A trained inspector examines the surfaces in the same manner as described for turbine discs, and no ring may be used until the metallurgical section has examined the prints and stamped it "O.K."

A detailed description of defects found in one such ring was given before the Staffordshire Iron and Steel Institute last year. On the Continent the writer has seen turbo-rotors being wound with steel tape, as in the manufacture of big guns, thus dispensing with forged-end rings.

Welding.—When defective material is encountered it must either be scrapped, modified or patched. Welding is frequently suggested as the cure. The writer has examined metallographically samples of various types of welding—oxy-acetylene, carbon arc, bare wire, covered wire, spot welds, eye-arc welds, and Hyde welds, and experiments have been made with non-ferrous methods of welding cast-iron analogous to brazing, but not all of these are applicable for the recovery of defective ferrous materials.

In the first place it must be realised that the material added in any type of welding corresponds at best to good cast metal of the same chemical composition. No weld ever equals good forged material. Hence it is obvious that the use of welding is limited to the recovery of cast-iron or cast steel articles by filling up blowholes or other such defects and to certain special cases where it is possible to build up a keyway, journal or other part that has been accidentally machined too far.

The writer believes that unstressed metal will never fail, and that fractures are due to the application of internally or externally applied stresses acting through a long period of time or in the form of a shock. Thus anything tending to increase the stresses in a material tends to decrease its life. Welding always sets up or increases internal stresses which are only released where thorough annealing is possible. Thorough annealing is practically impossible where a big casting has been machined to size, owing to the danger of warping. Small cracks or blowholes are frequently only discovered during final machining, and hence give rise to frequent metallurgical dilemmas. Weld and leave unannealed and perhaps crack the casting, or weld and anneal and perhaps warp it.

Where cast-iron is welded by the addition of molten steel from a filling rod or electrode a point to be borne in mind is that during the necessary cooling the added steel will contract practically twice as fast as the surrounding iron. All welding is subject to similar cooling stresses if only of less severity, and in any weld it is generally possible to detect minute cracks running into the metal at right angles to the general line of weld.

The phenomenon is particularly noticeable when the weld is elongated in section. Such cracks are not very important in cases where they are parallel with the line of stress. However, it is almost impossible to find an article possessing one simple line of stress, and as soon as such small contraction cracks receive a stress acting in a direction other than absolutely parallel with them they will cause a concentration of that stress at their ends and a consequent tendency to elongate and widen. Thus it would seem to be seldom advisable to allow welding in positions where severe temperature or stress changes are to be encountered, even if thorough annealing is possible after the welding operation is complete.

However, given a reliable operator—and the character of the operator is of fundamental importance—perfectly satisfactory welds can be made in most iron and steel castings, because in such cases the added metal is fairly comparable with the material pictured by the designer when he specified cast material for a lowly-stressed part.

The weld is a casting having the possibility of cold shorts, blowholes, slag inclusions, overheating and contraction cracks, at the same time as it has the possibility of being clean metal with a refined grain.

In connection with electric welding, two points have frequently been overlooked. Firstly, it is no good specifying very carefully what the carbon content of the filling wire should be as an indefinite but large percentage of the carbon content is burnt away during the welding operation. Secondly, it is not necessary to specify annealed wire for filling rods. Annealing increases the cost and may cause considerable oxidation, both of which characteristics are undesirable when it is

realised that the wire has to be melted in use and that previous annealing is therefore of no consequence.

Part II.—Laboratory Examinations.

Works Metallography.

Perhaps the most rapid and also the most informative method of examination of a piece of metal is that which is carried out by means of the microscope. The writer is convinced that the value of metallographic examination is very much underestimated in many (and probably in most) works. The reason for this lack of appreciation is to be found rather in the fact that most men are unable to transfer the picture seen with one eye at the bottom of a tube into the world of realities, than the fact that metallography is a relatively new branch of science.

The unreality of an object when viewed down a microscope tube is to a large extent overcome if the image of the object be projected on to a screen where it can be seen by several people at once in such a way that they are able to use both their eyes normally and are able to point out to one another special features of interest. The writer's experience with the usual type of microscopes is that it is a source of considerable nervous fatigue. The majority of metallurgical microscopes on the market were never designed throughout for the purpose for which they are sold. Hence one usually finds that the illuminator depends upon a prism or glass which is moved out of the best alignment with the source of light during the process of focussing.

If it is necessary to fix the prism or other vertical illuminator to the tube of a microscope provision should be made for obtaining the fine adjustment of the focus by moving the stage.

This trouble has been recognised and successfully eliminated by the Watson-Conrady attachment which gives excellent lighting for almost all normal visual examinations. In this attachment the source of illumination is a 4-volt electric light with a frosted bulb. This bulb is fixed together with two lenses, two iris diaphrams and a plane glass reflector—the components of the usual optical bench—in a small aluminium tube which is fastened by a screw attachment directly to the moving microscope tube.

It is thus impossible to move the vertical illuminator out of the most suitable position relative to the light. However, this attachment still leaves the use of the microscope coupled with the following drawbacks :—

1. Only one eye and only one person can see the object.
2. Time is lost and fatigue entailed when two or more persons must see a particular object.
3. Very long exposures are necessary for micro-photography.

When bitterly conscious of the above defects in the use of a works microscope, the writer had the good fortune to meet Mr. E. A. Atkins, of Warrington, who was kind enough to show him the way in which he had fixed up his microscope in a room that he was able to darken. He used a carbon arc light, cooling trough, condenser and iris diaphram in connection with a Watson microscope, all neatly set up in a large wooden cabinet in which provision was made for taking away fumes of the arc light. This type of cabinet is patented by Mr. Atkins, and had it been on the market at the time the writer would have endeavoured to acquire one. However, it was not on the market, and the writer therefore endeavoured to adapt the old Watson microscope which was at his disposal, for use as a projection apparatus. The method employed was different in many respects from that adopted by Mr. Atkins, who had the most up-to-date microscope and optical bench, fitted up in the conventional manner.

Firstly, the writer fitted his microscope on to a special wooden base in which a heavy metal plate, carrying a solid lamp support, could slide along grooves cut parallel with the microscope tube. A 500-c.p. Pointolite was obtained and shielded by means of a sheet metal screen in which a circular hole was cut opposite the simple bull's-eye lens used as a condenser. A plain wooden cabinet was made to fit over this base, for the source of light and the microscope, and above the light itself a simple light-proof ventilation chimney was fitted. The extreme simplicity of the whole projection apparatus is shown by Figs. 2 and 3. In this form it has been used for upwards of eighteen months for routine metallographic examinations, special demonstration and for micro-photography. Latterly, slight improvements have been made and the apparatus is now a recognised piece of permanent equipment.

For projection, magnifications of approximately 200, 700 and 1,600 diameters are obtained, using respectively a $\frac{2}{3}$-in., $\frac{1}{6}$-in. and a $\frac{1}{12}$-in. oil immersion objective. For photographic purposes, magnifications of 50 and 100 diameters meet nearly all requirements, and these are both obtained with the $\frac{2}{3}$-in. objective. With these magnifications exposures of about a quarter of a minute are sufficient when using a Wratten "B" screen. If no screen be employed the exposure is only a matter of a second, or even less, but the writer's experience is that the use of longer exposure entailed by the employment of a coloured screen, is fully justified by the improved definition obtained in the photograph.

With the apparatus here described it is possible to demonstrate, any particular type of structure or defect, to a number of people at once. The value of this is apparent even where the people in question are all perfectly conversant with the working of a microscope, but the value of this method of projection is many times greater where one has to deal with people who are not accustomed to the various adjustments and do not know the possibilities and limitations of a microscope.

The writer has used the apparatus illustrated to show sections of many of the metals and alloys manufactured or used in the works to works officials, superintendents, engineers, foremen, metal mixers, apprentices, &c. So simple in use and so superior in results is this method of projection, as compared to the usual one-eyed microscopical examination, that it was the practice of the writer to examine all specimens by projecting their image on the dark room wall at a magnification of 200 diameters. The standardisation of practice in this respect has made the recognition of grain size a more simple matter. Much time is saved and misunderstanding avoided in this manner when two or more people are interested in the examination, as is generally the case in works practice. The fact that both eyes can be used naturally is a great advantage.

Altogether this method of examination in a dark room using no eyepiece is thoroughly to be recommended for works practice. It could also be most usefully employed in academical work. The writer has used his apparatus for the latter purpose when demonstrating to a class of apprentices the nature of the metals they have handled.

Lack of funds has made it impossible to set up such a projection outfit at the university, but the writer hopes that he will be able to do so before long.

The Co-ordination of Data.—Metallography is perhaps the most rapid and informative method of examination available to the works metallurgist, but it is not an all-sufficing method. Mechanical testing, chemical analysis and other sources of information must all be tapped in some cases before applicable knowledge is available.

It has been noticed that most pieces of freshly-machined steel are magnetised, and also that certain small cracks invisible to the naked eye have been shown upon an oxidised surface when a knife-blade has been lightly moved over the oxide, or when iron dust is brushed over the surface. Such observations lead one to hope that the magnetic detection of defects will sooner or later become a regular and dependable means of examination similar to sulphur printing, but up to the present only limited use of this method has been possible.

The writer has deep etched sections of turbine and gear wheels and has received useful information in this manner, but this method of examination is also only of local effect, and is in many cases impossible of application. Large areas of the surface of big forgings have been deeply etched either with nitric acid or Stead's reagent and interesting flow patterns observed. Plasticene models have been prepared and sectioned. Defective steel has been examined by means of X-rays, but with little success so far as the development of a practical means of routine examination is concerned.

All these methods of examination may prove useful collectively or separately in certain cases, but where information is required in a hurry they are inapplicable. In such cases it has been found that the most useful information is obtained from the following :—

1. The microscope gives the nature of the material, cast, forged, rough chemical analysis, heat treatment, grain size.
2. The Brinell test gives approximate U.T.S. figure and fatigue value.
3. The Izod test gives notch brittleness figure.

If time allows for further testing the fatigue value of the metal is of great importance and should be obtained by means of some such tests as those developed in the National Physical Laboratory, *i.e.*, alternating torsion, which gives the fatigue limit as the point at which a definite break occurs in the heat development curve, and the method in which the fatigue limit is indicated by the point at which the deflection of a Wöhler test-piece, under increasing load, departs from proportionality to the load. A sensitive pyrometer is used in the first method, and a mirror fixed to the end of the specimen is observed from a distance by a telescope in the second method. Such tests have apparently confirmed the fact that the fatigue limit is approximately proportional to the U.T.S. Thus the routine tensile test of the steel in engineering works is an indication of the fatigue limit. However all such tests are only indicative as to local conditions as is clearly shown in the account of a research on ingot corner segregation. Similarly chemical analysis, though of undoubted value, only refers to the portion of the material analysed.

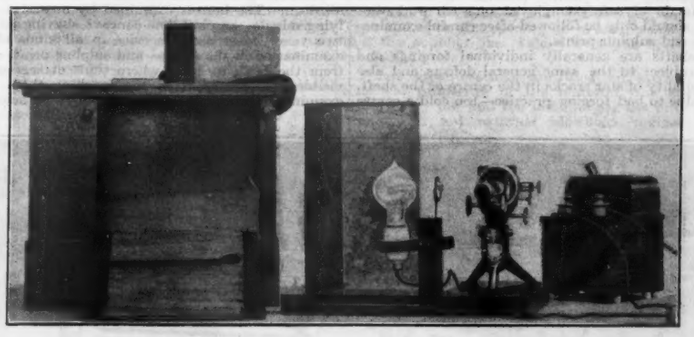

Fig. 2.

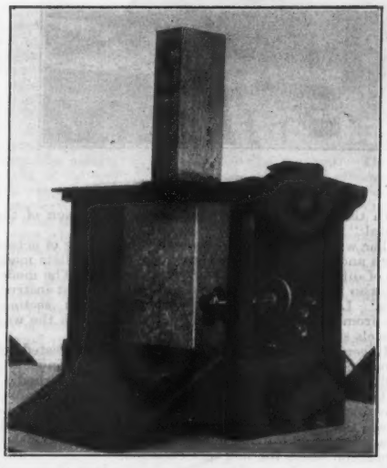

Fig. 3.

Thus the necessity of a most careful examination of the whole of the material and in the case of a fracture, of the actual fractured surfaces, is to be urged. Frequently the nature of the trouble is shown most plainly in such an examination. Wherever possible all such fractured surfaces should be retained and photographed.

The nature of the material is to some extent shown in the fracture and in a ductile material one can frequently notice wave markings and radial lines which indicate the point of initial failure.

The writer believes that for perhaps 90 per cent. of the cases requiring examination comparatively little expensive apparatus is required, in that a careful examination of the defective material *in situ*, sulphur printing or etching, followed by microscope examination and Brinell and Izod tests, is generally capable of giving the required information.

Expensive tensile testing machines, torsion testing machines, fatigue testing machines, and facilities for full chemical analysis are indispensable for the remaining 10 per cent. of the cases requiring examination. Such examinations can therefore only be undertaken in well equipped and well staffed research laboratories or by employing the facilities of a modern university.

Stresses in Boilers with Steeply-inclined Tubes.—Measurements of the stresses and displacements which may arise in boilers of the Stirling type, especially during the period of raising steam, have been taken by Dr. W. Otto, of Essen (*Zeitschrift des Vereines Deutscher Ingenieure*, November 3). Dr. Otto determined the temperatures at different parts of the boiler and fixed pointers, pulleys and pendulums so as to be able to measure the movements. The boiler in question had two upper steam drums and two lower water drums, the two upper drums being horizontally cross-connected, but Otto also introduced a cross-connection for the lower drums for experimental purposes. The lower drums were practically suspended from the upper drums by the systems of more or less vertical tubes which acted as springs tending by their expansion and contraction to lower and raise the lower drums. The displacements of the drums and tubes were naturally greater in the front which was exposed to the higher temperatures, than in the parts at the back; but the horizontal cross-connections transferred those strains to the rear. Displacements of the drum centres of 17 mm. and of the tubes by 12 mm. were observed. On the strength of his experiments Otto had a three-drum boiler constructed by the firm of Petry-Dereux, of Düren. In this there were two upper drums and one lower, the latter being vertically underneath the rear drum. The two upper drums are cross-connected by one tube of large diameter, the tubes extending from the steam drum downward to the lower are curved, those from the rear drum vertical. There are, further, baffles provided in the lower drum to maintain a good circulation of the water.